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EDITORIAL

THE ALL-CEYLON CATTLE SHOW OF 1939

THE Cattle Breeders' Association of Ceylon held its first Cattle Show last month and a note by Mr. St. Elmo Wijeyekoon, the Secretary of the Show Committee, published in this number of *The Tropical Agriculturist* gives an account of some of the exhibits. On all sides the show was pronounced to be a great success from the points of the interest evinced by the owners of cattle, of the quality of the animals shown, and of the efficiency of the organization. But this chorus of praise must not be allowed to drown the voices of criticism and of inquiry.

The exhibits came almost entirely from the neighbourhood of Colombo. It is unlikely that this phenomenon provides a true index of the regional distribution of cattle in the Island; nor was the show inadequately advertised. The true explanation appears to be that the expenses connected with the transport of cattle to Colombo from long distances and with their care and feeding in unfamiliar urban surroundings were greater than the average cattle owner was willing to bear. This was a problem which presented itself in India in connexion with the recent All-India Cattle Show held in New Delhi and was solved by the simple expedient of subsidizing the exhibitor. It is understood that the management of that show undertook the feeding of all the cattle during the week the show lasted and also paid a part of the cost of transport to and from New Delhi, while in many cases part of this cost was met by the provincial governments. Perhaps the Indian example would not fail to impress the Cattle Breeders' Association and the different public authorities in Ceylon. It may perhaps be possible in the future for a few progressive Village Committees to pay the expenses of one or two exhibitors from their districts.

Another marked feature of the show was the comparative unpopularity of the section of indigenous breeds. This confirms the opinion expressed by a special Committee of the Central

Board of Agriculture in 1937 that by inadequate care and feeding and by promiscuous breeding indigenous cattle had reached a very low stage of degeneracy. Nothing but the sustained effort of a number of generations can restore them to their rightful place in the agricultural economy of the country. There is no doubt that the Cattle Breeders' Association will pay its special attention to this problem. Perhaps it has a right to expect the Central Government to give some substantial financial backing to its efforts, and it may be suggested that the best form that this financial assistance can take would be the immediate vote of Rs. 10,000 to be given with the accumulated interest as a reward to the first registered breeder of a herd of pure local cattle which would reach a prescribed standard of milk yield.

While there was evidence that some excellent cattle existed in the country, they did not appear to be the product of planned breeding. They were not representative of a type or a standard which had been deliberately fixed as suitable for perpetuation in the country. On the contrary, most of them were either animals imported from abroad singly—like the champion cow of the show—or the casual crosses between imported animals of different breeds. It is doubtful whether, in the conditions in which they are kept and in which their progeny is disposed of, they will make any lasting contribution to the promotion of the policy of the Cattle Breeders' Association—the building up of a few large milking or beef herds each with a marked individuality of its own. It was indeed not expected that at the very first show held by the Association and within one year of its formation there would be any evidence of the fixation of types. The show was intended to provide only a display of the best original material available in the country for the purpose of regulated experiments in breeding, and it is most necessary that the public, the exhibitors, and the Association should realize that the success of the show did not go beyond the scope of this limited objective. The real test of the earnestness of the members will come when in a few years time they have to show the product of a programme of breeding.

ECONOMIC AND AGRONOMIC CONSIDERATIONS IN THE PROFITABLE LOCAL PRODUCTION OF ONIONS

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ONION is one of the oldest and the most extensively used vegetables. It is cultivated in almost every country where agriculture has been developed, and constitutes an important article of food. There are reasons for its wide popularity. It not only contains valuable nutrients but is credited with remarkable medicinal properties. Besides, it has the great merit of keeping quality for a fairly long period and power to withstand rough handling during transportation which has secured for it a place in international commerce.

There is an extensive use of onion all over Ceylon. It is popular in rural as well as urban areas and finds a ready market. There are chiefly two kinds of onions available in local markets. The first is known as Bombay onion which derives its name from the port from which it is shipped to Colombo. It is produced chiefly in Nasik and Poona Districts of the Bombay Presidency.

The Bombay onion is fairly large-sized and round-shaped and is mostly of light-red colour, but sometimes bulbs of silvery-white colour are also found in the market. Silvery-white coloured bulbs are of mild flavour and are valued comparatively high. The red-coloured bulbs which are most commonly found in the local market are fairly strong-flavoured. On the whole, Bombay onion fetches a comparatively higher price than shallots in the local market and is more appreciated.

The shallot has a compound bulb splitting into bulblets which cohere at the base. This bulb is small-sized, red in colour, strong in flavour and not so round in shape as the Bombay onion. Shallot is grown to a fair extent locally in the Jaffna and up-country districts. The requirements of shallots in the Island are supplied by such local produce as well as by imports from the port of Tuticorin which is the exporting centre for the produce of South India.

It is rather difficult to find out in exact terms the total amounts of onions annually consumed in this country. Exact figures of local production are not available. The following statement

of the quantity and value of imports of onions during the last two years shows that more than two million rupees worth of onions are imported every year.

Quantity and Value of import of onions in Ceylon during the years 1936 and 1937

Year	..	1936	..	1937
Quantity in cwt.	..	608,831	..	635,873
Value in rupees	..	2,012,134	..	2,049,404

Wherever this crop is cultivated in India, it is regarded as one of the most profitable garden crops in village agriculture. The cost of production is not very high, provided right methods of cultivation are followed. Its cultivation does not demand very specialized skill, and the details of cultural practices are simple enough to be grasped by any intelligent cultivator. Climatically, some of the districts in Ceylon are likely to prove quite suitable for the cultivation of onion, more especially the Up-country districts. The prevailing local wholesale price is about four cents per pound, whereas in the villages of the Bombay Presidency it is less than a cent per pound ; yet it is a profitable crop there. These facts clearly indicate that the possibilities of profitable local production of Bombay onions are very great. There is hardly any other crop that can offer so splendid an opportunity for profitable cultivation as this. It is, therefore, proposed to outline in the pages that follow the details of the important cultural practices associated with the cultivation of Bombay onions in the important onion growing districts of the Bombay Presidency.

HABITS OF GROWTH OF THE BOMBAY ONION

Onion is generally regarded as a biennial except in the case of some forms such as shallots which are of perennial character. As a biennial Bombay onion has two distinct stages of growth, the first, the vegetative stage in which bulbs are produced by the planting of seed or by transplanting seedlings raised from seed, and the second, the reproductive stage in which seeds are produced by the planting of the bulbs raised in the preceding season. The life of a complete Bombay onion crop is thus of two years' duration. However, a large part of this crop is raised for its bulbs and therefore it is taken as an annual crop, and a small part of the area is devoted to the production of seed.

VARIETIES

There are two chief varieties found in the local market and grown in the Bombay Presidency. The strong-flavoured, red variety occupies a predominating position because it is of a hardy character, is a high yielder, has a large-sized bulb with a comparatively thick skin which enables it to withstand handling during

transport better, and has better keeping quality. The white is a mild-flavoured variety and although, on that account, it fetches a better price, it is not as hardy and high-yielding as the red variety, and its skin is comparatively thin while it cannot withstand the strain of handling to the same extent as the red variety. Its bulb is also comparatively small-sized. The cultivation of this variety is therefore limited.

CLIMATIC REQUIREMENTS

Onion is essentially a winter crop in India. For best results, onion requires a cool climate with plenty of moisture during the early part of the growing period and a relatively dry atmosphere and moderately high temperature during the latter part which help a great deal in proper ripening. In parts of Bombay Presidency where onion cultivation has become established as a permanent industry, the crop is transplanted from the middle of October to the middle of November and harvested in April when there is a fair amount of heat and absence of rain. If it rains during the harvesting period, it will not be possible to cure the bulbs properly and thus the keeping quality will be seriously affected. It is, therefore, desirable to decide on the planting time after fully considering the local conditions so that there should be no possibility of rain at the time of harvesting. The author has grown this crop on the Agricultural College Farm, Poona, for five years and has obtained yields ranging from 31,000 to 37,000 lb. bulbs per acre under ordinary good conditions in some years. The highest yields were obtained in the years 1931–32 and 1932–33. A study of the climatic conditions during the growing period of these two years on the Agricultural College Farm, Poona, which are presented in a statement below in weekly periods, will give a fair idea of the climatic requirements of this crop.

TABLE 1

Climatic conditions by Weekly Periods, 1931–32

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week.		Mean of humidity.
			Maximum.	Minimum.	
November, 1931	First	2·80	85·8	66·5	86·7
,,	Second	0·05	83·1	63·2	86·7
,,	Third	—	84·3	51·5	75·3
,,	Fourth	—	84·4	52·8	75·4
December, 1931	First	—	82·5	47·1	75·5
,,	Second	0·27	76·7	56·4	85·2
,,	Third	—	81·2	56·3	91·1
,,	Fourth	—	83·2	46·6	79·8

TABLE 1—*contd.*

Climatic conditions by Weekly Periods, 1931–32

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week		Mean of humidity.
			Maximum.	Minimum.	
January, 1932	First	—	84·5	46·1	80·4
,,	Second	—	83·2	46·8	74·7
,,	Third	—	86·1	47·8	74·7
,,	Fourth	—	90·5	47·5	71·4
February, 1932	First	—	87·7	48·1	82·2
,,	Second	—	87·7	49·2	78·2
,,	Third	—	86·8	49·7	73·0
,,	Fourth	—	90·4	55·3	82·8
March, 1932	First	—	93·6	58·3	75·7
,,	Second	—	96·8	56·1	78·5
,,	Third	—	99·3	58·8	71·7
,,	Fourth	0·03	99·6	61·7	60·9
April, 1932	First	—	101·8	66·0	63·7
,,	Second	0·54	103·2	70·4	72·6
,,	Third	—	99·0	64·2	71·1
,,	Fourth	0·17	101·0	69·5	76·9

TABLE 2

Climatic conditions by Weekly Periods, 1932–33

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week		Mean of humidity.
			Maximum.	Minimum.	
November, 1932	First	0·08	86·8	62·0	83·3
,,	Second	—	86·0	49·7	78·0
,,	Third	1·03	86·6	59·6	81·0
,,	Fourth	—	84·2	60·5	81·6
December, 1932	First	0·59	86·3	55·3	88·7
,,	Second	—	84·5	50·7	78·9
,,	Third	—	84·7	44·6	74·4
,,	Fourth	—	84·3	48·1	78·7
January, 1933	First	—	86·1	49·0	84·2
,,	Second	—	85·2	45·7	78·0
,,	Third	—	89·7	51·0	82·6
,,	Fourth	—	85·3	48·1	89·1
February, 1933	First	—	91·2	52·8	83·1
,,	Second	—	92·7	53·1	79·2
,,	Third	—	91·3	50·5	77·2
,,	Fourth	—	90·0	52·6	79·0
March, 1933	First	—	94·8	53·6	72·7
,,	Second	—	97·7	60·0	76·4
,,	Third	—	98·9	61·1	76·2
,,	Fourth	—	97·6	60·0	73·1
April, 1933	First	—	103·6	62·9	67·3
,,	Second	—	97·7	69·9	65·2
,,	Third	—	102·9	71·0	59·3
,,	Fourth	—	100·8	66·7	59·5

From the climatic point of view, therefore, certain up-country districts of Ceylon may prove suitable for the cultivation of this crop. The Jaffna District, although it does not have such low minimum temperatures as Poona, grows with a fair measure of success crops such as cabbage and cauliflower and, therefore, it may be possible to grow this crop, too, there. A few preliminary trials would clearly indicate the extent to which this crop can be successfully introduced in Jaffna District.

SUITABLE SOILS

The best soil for onion is a rich sandy to clay loam which is freely workable, retentive of moisture and yet well-drained, of fair depth and well supplied with organic matter. Heavier loams do yield profitable crops when properly handled, but should receive a sufficient amount of organic manures to prevent baking which damages the growing plants. The main requirements are a high state of fertility, excellent physical condition or tilth, sufficient drainage in places of heavy rainfall and freedom from weeds. Stiff, water-stagnated and low-lying lands are not suitable for this crop. Lighter types of soils produce bulbs with a brighter skin than those produced on heavier soils. Onion is not able to tolerate strongly acidic soils, whereas on slightly alkaline soils, it produces a fairly good growth.

METHODS OF CULTIVATION

This, being a very profitable crop, offers special inducement for the employment of intensive cultural methods. The cultivation of onion is not difficult in itself, but close attention and frequent cultivation for the control of weeds are necessary. If weeds are not effectively controlled from the very start, the cost of subsequent control will be high and the yield will be appreciably reduced. It is, therefore, desirable that onion should follow a crop which has remained free from weeds. Again, this crop should not be planted year after year on the same land, but some system of crop rotation should be adopted because continuous cropping is likely to cause the land to be infested with pests to such an extent as to render it unprofitable for future cultivation. Crops like beans, grams, groundnuts, sweet potatoes or green manure crops can with advantage be included in the rotational cropping scheme.

PREPARATORY CULTIVATION

Land intended for this crop should be thoroughly well prepared. The old saying "as fine as onion bed" has its significance. Operations of preparatory tillage such as ploughing, harrowing and levelling sh ould be properly carried out. As the crop is a surface feeder, ploughing to a depth of 6 to 7 inches is sufficient. Farm-yard manure or compost, at the rate of 10 tons per acre,

is spread over the land and incorporated into the soil during the course of subsequent harrowing operations. The land should be brought to as level a condition as possible so that there may be no difficulty at the time of irrigation.

PLANTING

The most common method of planting this crop in the Bombay Presidency is to sow the seed in specially prepared, raised nursery beds and to transplant the seedlings in the permanent field when they are about six weeks old. The chief advantages gained by the transplanting method are a great economy in the cost of planting material, an opportunity to reject unhealthy and inferior seedlings, a uniform stand and bulbs of regular size.

An area of about 1,600 to 1,800 square feet of nursery beds is required for raising seedlings sufficient to plant an acre. Farmyard manure, at the rate of about 25 tons per acre, is applied to nursery beds which are then prepared in a manner similar to the broad ridges intended for planting ginger or turmeric. These beds are about 3 feet wide at the top surface, and are as long as the level of the land will permit of even distribution of water. The beds should be fairly compact so as to ensure good germination. Seeds are sown evenly on these beds in shallow furrows 3 to 4 inches apart across the bed. Ten pounds of seed will produce seedlings sufficient for transplanting an acre of land. Nursery beds require to be lightly watered and weeded frequently. Seeds complete their germination within a week. By six weeks' time when the seedlings are 5 to 6 inches high, they are ready for transplanting.

The land for transplanting onions can be laid out in two different ways. The flat bed is most commonly followed, and it is particularly suitable on lighter types of soil. The great advantage in its favour is that it permits of the production of medium-sized, round-shaped, uniform bulbs without much splitting and bifurcating. The bulbs obtained from this method have better keeping quality. The other is the ridge and furrow method chiefly adopted on heavier types of soil so as to prevent stagnation of water. Ridges are prepared 18 inches apart and water channels across the ridges and furrows are opened 12 to 16 feet apart for effective and even distribution of water. Seedlings are transplanted on both sides of the ridges. The bulbs obtained by this method are relatively large-sized and much more succulent and watery, but splitting and bifurcation occur to a much greater extent. The quality is therefore inferior.

In order to make the uprooting easy, the nursery beds are irrigated in the evening before the day of transplanting. Seedlings are carefully uprooted just before they are required for

transplanting and carried to the place of transplanting in baskets with mud adhering to the roots. Immediately before transplanting, the beds or furrows are irrigated and, when sufficient soaking has taken place, the seedlings are transplanted in the moist land at the rate of only one seedling in each place. More than one seedling is undesirable as that would retard the healthy growth of bulbs. The spacing between plants on the sides of the ridges is 4 inches. In flat beds the spacing of 9 inches by 4 inches is provided. There is a tendency among some farmers in canal-irrigated areas to transplant seedlings too widely apart. This results in delay in maturity and in unduly large-sized bulbs which have a tendency for splitting and bifurcation. Closer planting is therefore an advantage from the point of view of quality as well as quantity. About 25 to 30 women are required to transplant an acre of land in a day. The crop requires during its early stage ample moisture close to the plants for the development of the root system. Therefore, continuous mild rain or comparatively frequent irrigation is required in the first fortnight. If the planting is done during the dry period, a second irrigation on the third day, a third and a fourth irrigation at an interval of four or five days are necessary. The crop gets established within a week. In the case of seedlings that have failed to establish within 10 days, the gaps are to be promptly filled in.

MANURING

Over and above the organic manure incorporated into the soil during the course of preparatory tillage, it is necessary to supply artificial fertilizers on account of the intensive character of cultivation. Rao Bahadur D. L. Sahasrabuddhe, the former Agricultural Chemist to the Government of Bombay, in Bulletin No. 174 of the Bombay Agricultural Department, states that an average onion crop yielding 14,000 lb. of bulbs, removes from the soil 47·6 lb. nitrogen, 27·8 lb. phosphoric acid, 52·4 lb. potash and 38·9 lb. lime. The author carried out intensive field experiments for a period of five years on the Agricultural College Farm, Poona, under the guidance of Mr. V. G. Gokhale, then Professor of Agriculture and Principal, College of Agriculture, Poona, with a variety of fertilizers in order to ascertain the manurial requirements of this crop. The results clearly demonstrated that phosphoric acid and potash did not appear to be important yield-increasing elements and sometimes they even depressed the yield. Nitrogen in the form of sulphate of ammonia or nitrate of soda at 40 lb. nitrogen per acre, that is, 192 lb. sulphate of ammonia or 266 lb. nitrate of soda per acre, improved the yield to a very marked extent resulting in statistically significant increases and high economic returns. These nitrogenous fertilizers are applied as a top-dressing about three weeks after transplanting.

AFTER-CULTIVATION

Onion is a fairly hardy and drought-resistant crop and, therefore, need not be over-irrigated after the first growth has commenced. Excessive irrigation results in unduly high succulence of bulbs which is not a desirable feature from the point of view of keeping quality. However, the plants must be kept growing. Early in the season, the growth is particularly rapid and if it is checked temporarily owing to shortage of water, the outer scales appear as if matured. When irrigation is again given, the inner scales resume growth, thereby splitting the outer ones. This is one of the primary causes of splits and doubles when onion is grown under irregular irrigation. During the dry period, the fifth and subsequent irrigations till the crop attains maturity are given at an interval of 7 days in light loamy soils and 10 days in clay loam soils.

Other chief requirements are frequent stirring of the surface soil and removal of weeds, care being taken to avoid damage to the feeding roots. On account of close planting, bullock intercultivation is not possible. In the case of the ridge and furrow method the ridges and furrows, and in the case of flat beds the surrounding bunds, require to be periodically repaired. If the surface soil is rendered too compact by the beating action of heavy rain, it should be loosened by breaking the crust by means of a rake or weeding hook.

The crop finishes vegetative growth in about 3½ months of transplanting and soon after this the flowering tops known as "poles" begin to appear. For a bulb-crop the growth of poles is not to be encouraged as the nutrition available to bulbs is thereby diverted to the rapidly growing poles. The poles are therefore cut off soon after they appear and, to prevent their growth in the case of other plants, the necks of the plants are pressed down by running a wooden plank over the field. If the area under cultivation is small, the necks of plants can be pressed under human feet. The pressing down of necks also helps in quick ripening of the bulbs. Irrigation is stopped at this stage and the bulbs are allowed to ripen under dry conditions. When the leaves, after turning yellow, begin to droop and when the outer skins of the bulbs appear dry, the crop is considered ready for harvest. It is not desirable to allow the crop to stand on the land for any length of time after the tops have died as the bulbs are then damaged by exposure to sun or they are likely to be ruined by a spell of wet weather. The interval between transplanting and harvesting ranges from 4½ to 5 months.

HARVESTING

The crop is harvested by uprooting by hand the mature plants with the bulbs. As the onion bulbs are very close to the surface

soil and as they are very shallow-rooted, no difficulty is experienced in harvesting by this method. After uprooting the bulbs, the roots and the leaves should be cut off and the adhering earth removed. Loose, thin, outer papery scales should also be removed. Bulbs that have been damaged or are bifurcated should be separated as they cannot keep well during the storage period On an average a woman can harvest and clean 500 to 600 lb. of bulbs in a day. They are then thinly spread under shade and allowed to dry. Care must be taken to guard against bruising while handling the bulbs. They should be kept in as cool and dry a place as possible.

YIELDS

The average fair yield of this crop in Nasik and Poona Districts is 13,000 to 20,000 lb. per acre. When the crop is badly attacked by pests, the yield is much below the average. Under good cultivation and when the crop is free from a severe attack of pests, the yield easily ranges from 25,000 to 40,000 lb. per acre.

STORAGE

As the onion is in demand throughout the year and as it is capable of successful storage with proper care and precaution, it offers an opportunity for the producer to realize his best price after the glut of the harvesting season is over. The Indian farmer, however, does not himself undertake the storage of onion as a local dealer is almost always available to purchase his crop immediately after harvest. It is the dealer who takes up the business of storage.

Onions can be stored with minimum loss in large quantity if they are kept in a dry, cool and well-ventilated place. Special storage houses prepared from grass thatchings are constructed by wholesale onion dealers. The walls of these storage houses are made of split bamboos with vacant spaces between them so as to admit ample circulation of air.

Thick necks or those that are not fully matured and are soft should not be brought for storage along with other good bulbs. Satisfactory drying to drive off unduly high moisture content is quite essential before successful storage. Drying of the outer skin to a fine papery texture and the feeling of brittle touch are indications of satisfactory drying. A serious trouble of wet rot will spread if insufficiently dried onions are taken to the storage house. There is considerable loss in storage due to drying of bulbs as well as to damage caused by rotting. In Bombay, this loss sometimes amounts to from 25 to 40 per cent. during a storage period of six months, but it is amply compensated by high prices obtainable off season. On account of the relatively low maximum temperature prevailing in most parts of Ceylon, the storage losses are likely to be comparatively low in Ceylon.

Onions should not be heaped too high in stores but should be thinly and evenly spread allowing free circulation of air. Bulbs when kept on racks made close together will economize storage space and will be stored better. For short periods bulbs are sometimes stored in gunny bags in well ventilated places. The storage houses require to be periodically examined to sort out and remove the rotten bulbs.

PESTS

The crop is chiefly liable to an attack of thrips which crowd on the surface of the leaf and suck the sap. This results in appreciable loss in the vitality of the plant, and leaves become white-spotted, curl and die. This trouble appears to be responsible for interfering with the physiological processes concerned with the development of the bulb and hence the yield is directly affected. The attack which largely depends on the climatic conditions is not of an equal magnitude in all the years. In mild form it does not cause serious reduction in yield. A severe attack, however, reduces almost by half the yield of an apparently promising crop. The attack of thrips can be controlled to some extent by the timely spraying with nicotine sulphate solution. A heavy shower of rain washes away a large number of thrips and the crop then improves.

METHOD OF SEED PRODUCTION

In the case of a crop like onion where the viability of the seeds is limited to one season only, it is not a good policy to rely on outside sources for the supply of seed. The seed so purchased, besides being costly, is likely to be of doubtful germinating power. Whenever possible, the farmer should make provision for growing his own requirements of seed on a small area in the corner of his main bulb-crop. Most of the onion growers in India raise their own seed, and by so doing they produce seed that is better adapted to their specific local requirements than the supplies generally procured from markets.

Though the plants raised from seed send out flowering shoots in a single season, the seed obtained is not of good quality and cannot be relied upon to produce a crop of bulbs. In order to obtain seed capable of developing into a desirable type of bulbs, a limited number of well-developed, medium-sized bulbs of the best appearance are selected from a bulb-crop and they are given 4 to 5 months' rest by providing careful storage and are then utilized for planting.

For the production of seed, the climate should be cool and moist till the commencement of flowering, and then fairly warm and dry without rain. The period of harvesting and curing of seed should be necessarily dry.

The land intended for seed production receives the same thorough preparatory cultivation and liberal manuring as that for raising a bulb-crop. Ridges and furrows, 2 or 2½ feet apart, should be opened by a small ridger or Victory plough. Sets for planting are prepared by rejecting a portion of about one-third of the top of the bulb; only the rest of the bulb is utilized for planting. If the upper one-third part is not removed at the time of planting, all the poles will have to force their way out through one mouth only. The cutting away of the top part permits of easy passage for the emerging poles and stimulates vigorous leafy growth. About 1,000 to 1,200 lb. of bulbs are required to plant an acre. The sets are planted in furrows at a spacing of 1½ feet and covered over with a layer of soil about 2 inches thick.

Planting season, frequency of irrigation, requirements in weeding and soil-stirring are practically the same as with the bulb-crop. When the plants are about a foot high, that is, after about six weeks' growth, the crop is earthed up and made to stand on ridges. Within a fortnight of earthing up, on an average 5 to 8 shoots with flowering heads come out from each bulb. The crop is ready for harvesting in 4½ to 5 months.

The crop is not harvested in one operation. The heads are to be collected as they are ready at an interval of 4 or 5 days by cutting them one by one, with a short piece of stalk attached, by hand. The proper time to harvest is when the seed after passing the dough stage has begun hardening and has assumed a deep black colour. Black colour alone is not dependable as an indication of ripening as the seed assumes a black colour at a much earlier stage before maturity. Seed stalks, when mature, must be promptly collected and, if delayed, a great portion of seed is lost by scattering. The heads are then spread over a mat in a drying place in a thin layer and allowed to dry in the sun. They are turned over daily until they are dry enough to be threshed. Threshing is usually done by beating with wooden flails and seeds are finally cleaned by careful winnowing.

In some places there is a pratice of separating the good heavy seeds from the inferior light ones by putting them in a shallow vessel containing water. Those that float are light and are discarded. The heavy seeds which sink should be taken out at once and allowed to dry fully. However in places where the weather is uncertain and the seeds cannot be quickly dried owing to unexpected rain, this method of separating out light seeds is not safe and should not be practised.

A good average crop yields about 300 to 450 lb. seed per acre.

SOME SOIL AND MANURIAL PROBLEMS OF CITRUS CULTURE IN CEYLON

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THE area under systematically-cultivated citrus in Ceylon has been slowly but steadily extending during the past few years and is likely to be further extended in the future. It is, therefore, essential that those who grow or contemplate growing the crop should be acquainted with some of the important soil and manurial problems affecting successful citrus culture in the Island.

Citrus trees do best on deep, well-drained, medium loams with no physical obstruction to root development and water movement within a soil depth of about 4 feet. Thus low-lying, clay soils in which water drainage is impeded, very hard laterite (cabook) soils such as not infrequently occur in the humid low-country, soils in which the permanent water table is too near the surface, and those with an impervious heavy clay or hardpan sub-soil are unsuitable, or, at any rate, unfavourable for the crop unless ameliorative measures, *e.g.*, surface and sub-soil drainage, are adopted. Even so, it is doubtful whether the returns would, in many cases, be sufficiently remunerative to justify the expenditure involved. Soils with a gravel sub-soil, especially in dry and semi-dry areas where irrigation is not feasible, and those which are too rocky are also not generally to be recommended.

From the chemical standpoint citrus soils should be well supplied with organic matter and nitrogen, available lime, potash and phosphoric acid, and should contain a sufficiency of the minor elements, *e.g.*, boron, necessary for the health of the trees. Soils containing an excess of organic matter or lime are, however, to be avoided as, on such soils, the trees develop certain physiological disorders and become unhealthy. Fortunately these soils are extremely rare in Ceylon. On the other hand, strongly acid soils such as the wet patana or the laterite soils, are disadvantageous for more than one reason, the chief being their lack of lime. Soils which are strongly alkaline and contain excessive quantities of soluble sodium and magnesium salts are also unsuited to the crop. These, again, occur but seldom in Ceylon.

Citrus is a crop which absorbs large amounts of plant food from the soil. It has been reckoned that an acre of citrus giving average yields removes from the soil about 55 lb. nitrogen, 12 lb. phosphoric acid, 45 lb. potash and 85 lb. lime. It is obvious, therefore, that if citrus is to be grown as a commercial proposition it has to be fairly heavily manured and limed.

An essential requirement for successful citrus cultivation is an adequate amount of soil organic matter. Ceylon soils are generally deficient in this respect. The deficiency should be made good by the application of farmyard manure, compost and green manure. A fully-bearing citrus tree could receive with advantage up to about 200 lb. of farmyard or other bulky organic manure per annum. A suitable time of application is soon after the crop has been picked. Younger trees should receive proportionately smaller amounts. Green manure could replace farmyard manure in part, but, where cover crops are grown, it is essential that they be turned into the soil or cut and left as a mulch on the surface before the drought sets in. It is the experience of growers in certain citrus-growing countries that a permanent cover in the grove affects both the growth and yield of the trees adversely. This is due to the competition between the roots of the main and the cover crop for the moisture and nutrients of the soil. Recent work at the Experiment Station, Peradeniya, by the Demonstrator in Plant Propagation has confirmed this observation.

For the healthy growth of citrus an adequate supply of lime in the soil is necessary. Citrus trees absorb large quantities of calcium, their demands for this element becoming greater with advancing age. It has been found that calcium constitutes about a third of the ash content of healthy citrus leaves, while mottled or chlorotic leaves, *i.e.*, those which have developed a characteristic yellowing, in part or whole, have much lower proportions of this element. An acute and prolonged deficiency of calcium results in the mottling and chlorosis of the leaves, the die-back of the branches, poor crop yields and ultimately even the death of the trees. The periodical liming of citrus trees is therefore of fundamental importance in all but a few areas where the crop is grown. The main exceptions are those where the soils are derived from Miocene limestone, *e.g.*, parts of the Jaffna Peninsula, or associated with crystalline limestone as in the Matale–Dambulla district. Even in these areas, on certain soil types citrus will benefit by liming. It is tentatively suggested that where lime is applied the annual application be varied from 4 to 15 lb. per tree, depending on its age. Experiment might indicate that larger doses are necessary.

A deficiency of lime in the soil is only one of several causes of chlorosis in citrus. Others are unsuitable physical soil conditions such as those already enumerated, unfavourable chemical conditions, *e.g.*, excess of lime, low iron availability, deficiency in the minor elements, zinc, boron, manganese, magnesium, copper, incompatibility of stock and scion, eelworm, &c. But evidence is forthcoming that trees grown on naturally calcium-deficient soils and which have not received adequate applications of lime are most liable to chlorosis. Certain species of citrus, *e.g.*, mandarins, are more susceptible than others, but none is immune. Owing to its fairly wide prevalence in Ceylon, citrus chlorosis is at present engaging the attention of the Departmental officers concerned with the subject.

In regard to artificial fertilizers for citrus, numerous experiments in other countries have shown that the best response is obtained with nitrogenous fertilizers. Local experience confirms this finding. Potassic and phosphatic fertilizers are also beneficial on many local soils and essential on the sandy soils which are deficient in these elements. Especially when bulky organic manures are used in insufficient quantity, part of the nitrogen applied to the crop might be given in organic form, *e.g.*, as blood meal. Any of the ordinary nitrogenous or compound nitrogen and phosphoric acid fertilizers may be applied, but information in regard to the use of cyanamide for young citrus locally is scanty. Superphosphate and basic slag are suitable phosphatic fertilizers to apply. The latter is particularly advantageous on acid soils. Potassium is best given as sulphate of potash, but kainit has advantages on certain types of soils.

Only brief reference will be made to the questions of fertilizer mixtures suited to different soil and climatic conditions, and the best times and methods of application. Definite data on these points have yet to be obtained from carefully planned field trials. With the establishment of a Government citrus plantation at Minneriya, the investigation of some of these problems will be taken in hand. In the meantime the following mixtures, based on the experience of other citrus growing countries and a consideration of local soil conditions, are suggested for trial on soils of average fertility, as they have been found to give beneficial results where tried :—

3 parts sulphate of ammonia or nitrate of soda
2 to 3 parts superphosphate or basic slag
1 part sulphate of potash

at the rate of 4 to 10 lb. per *bearing* tree, annually, depending on the age. The suitable combination of nitrogenous and phosphatic fertilizers should be used. The mixture is advantageously applied about a month before flowering. A month

or so after the setting of fruit 1 or 2 lb. of sulphate of ammonia or nitrate of soda per tree may be given, the quantity varying with the age. Manuring should not be done in very wet weather nor in times of drought. A period of light rains is the most favourable.

In regard to methods of application, experiments abroad have indicated that soluble fertilizers are best applied dissolved in the irrigation water. Where this is not practicable it is suggested that fertilizers and manures for citrus be broadcast and fairly deeply forked into the soil within a circular area extending from a distance of about 2 ft. from the trunk to about 1 ft. beyond the circumference or drip of the tree. Care should be taken that no thick roots are damaged in the process.

It may be useful to refer briefly to the question of irrigation for citrus. It would be futile to attempt to grow citrus as a commercial proposition in the dry zone without some form of irrigation. Generally speaking an irrigation about once a fortnight should suffice during the period of drought. The quality of the irrigation water is important. It has been found in Palestine that irrigation water containing more than 350 parts per million of chlorine is generally unsuitable for the crop. Very brackish water should, therefore, be avoided for the purpose.

If citrus cultivation on a large scale is to be profitable, it is essential that the land be carefully selected, irrigation facilities provided if the area is in the dry zone, and due attention be given to the cultivation, liming and manuring of the trees.

CHEMICAL AND AGRICULTURAL NOTES FROM THE COCONUT RESEARCH SCHEME, CEYLON

III. LOSS OF AMMONIA FROM FERTILIZER MIXTURES CONTAINING SULPHATE OF AMMONIA AND MINERAL PHOSPHATES

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THE question of possible losses of nitrogen (as ammonia) when sulphate of ammonia and ground mineral phosphates (such as Saphos, Ephos and Safaga phosphates) are mixed is one of considerable practical importance. It is usually recommended that these constituents may be safely used in manure mixtures, but the possibility of the presence in mineral phosphates of 10 to 15 per cent. of lime as calcium carbonate which will react with sulphate of ammonia under damp tropical conditions should not be ignored.

Akhurst (1), working at the Rubber Research Institute, Malaya, in 1936, using mixtures of sulphate of ammonia with three different types of rock phosphates (Christmas Island, Gafsa and Cheribon), showed that appreciable losses of nitrogen can occur from the mixtures on storage. Losses of nitrogen amounting from 7 to 13 per cent. were observed after six days, and from 16 to 17 per cent. after 13 days.

Very similar results were obtained by Beeson and Jacob (2) working at the U. S. A. Bureau of Chemistry and Soils. Using calcined rock phosphate it was shown that the losses which occur are small when all materials are kept dry, but considerable when the humidity is high, particularly when potash salts are present.

Some results obtained in the Coconut Research Scheme laboratory are worth recording.

Two parts sulphate of ammonia, four parts Saphos phosphate, and two parts muriate of potash, in the proportions generally used in manure mixtures for coconuts were thoroughly

mixed and aliquot portions were stored in small miniature manure bags. Determinations of ammonia were made periodically.

Even at the time of mixing a distinct smell of ammonia was observed. That appreciable losses of ammonia occur is shown by the following data :—

	Nitrogen Per cent.		Loss of Nitrogen Per cent.	
At Mixing.	After 9 days.	After 1 month.	After 9 days.	After 1 month.
5·69	5·40	4·65	5·2	18·3

Beeson and Jacob (*loc. cit.*) report that the loss of nitrogen increases with the relative humidity of the air ; and that the rate of loss depends on the initial moisture content and the relative proportion of the mixture exposed to the atmosphere. Mixtures containing below one per cent. of moisture do not lose ammonia when stored in closed containers.

It is not necessary here to discuss the chemical reactions occurring in the mixture, beyond pointing out that the presence of " free lime " in the original phosphate is not essential for the liberation of ammonia. Beeson and Jacob (*loc. cit.*) indeed point out that in the presence of water α tricalcium phosphate can decompose sulphate of ammonia.

Whatever the chemical reactions may be, losses of nitrogen as ammonia are found to occur from fertilizer mixtures containing sulphate of ammonia and mineral phosphates when these are stored for any length of time under the hot and humid conditions of most Ceylon coconut districts. The effect is enhanced by the presence, in the mixture, of potash salts which rapidly absorb moisture. In the trial reported here, the mixture after two months had become a damp, sticky mass resembling puddled clay.

Separate application of the constituents of such a mixture would probably be unobjectionable, but a large proportion of coconut estates use ready-mixed fertilizer mixtures, and since the time of application of manures depends upon the vagaries of weather, long storage is often inevitable. Accordingly, the use of sulphate of ammonia with mineral phosphates in mixed fertilizers is not recommended.

It is possible that different degrees of loss will be found with different grades of phosphate and it is proposed to carry out further investigations in co-operation with the Tea Research Institute.

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THE CONTROL OF THE GIANT SNAIL (ACHATINA FULICA FER.) AT THE TABBOWA VEGETABLE SEED STATION BY THE USE OF "META-BRAN" BAIT TRAPS

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THE prevalence of snails at the Tabbowa colony during 1937 and 1938, and the vast amount of damage to agricultural crops resulting from their attack in the area led to a trial of the new "Meta-Bran" bait which has been suggested as a measure of control. The trial, which was conducted at the Tabbowa Vegetable Seed Station, was commenced in November, 1938, and forms the subject of these notes.

PREPARATION OF THE "META-BRAN" BAIT

In preparing the bait, half an ounce of "Meta," thoroughly powdered, was mixed with 1 lb. of rice-bran in a bucket. The mixture was then gradually wetted with warm water and well stirred to a consistency of a mash which could be easily moulded into balls, each the size of a small lime fruit. About 26 oz. of water were required to make 1 lb. of bait from which 60 bait-balls were prepared.

SETTING OF "META-BRAN" BAIT TRAPS IN THE FIELD

The prepared "Meta-Bran" bait-balls were placed in the field at intervals of 15 feet throughout the infested area. As the baits are easily washed away by rain and adversely affected by hardening if exposed to the intense heat of the sun, they were covered over with lengths of corrugated iron sheetings 9″ × 8″ shaped to form a protecting hood over each bait. These hoods proved to be exceedingly useful in the field.

During rainy weather, when snails are usually most prevalent, it was found necessary to increase the number of baits placed in the field by reducing the interval between the traps to 10 feet.

Whenever the baits showed signs of hardening and drying, they were collected into a bucket, broken up, wetted with warm water and re-moulded into baits. In this manner the bait-balls can be used over and over again until they have been consumed by the snails :—

COLLECTION AND DISPOSAL OF SNAILS

The snails were usually attracted to the baits at night and were found dead the following morning. The dead snails were collected daily and buried, leaving the baits exposed for a further catch.

The following table shows the results of the trial conducted at the Tabbowa Vegetable Seed Station from November 3, 1938, to February 28, 1939 :—

Period.	No. of Traps.	No. of Dead Snails collected from Traps.	Rainfall. Inches.
November 3–30, 1938	88	4,462	5·63
December 1–31, 1938	432	8,682	3·98
January 1–31, 1939	500	71,814	4·9
February 1–28, 1939	550	22,080	0·23

The results so far obtained of snail control by the use of "Meta-Bran" bait traps have been most encouraging, and the trials will be continued during the rainy season.

COST OF "META-BRAN" BAITS

The cost per acre of "Meta-Bran" bait, worked out on the assumption that the baits are placed in the field at 15-foot intervals, and using the concentration of half an ounce of "Meta" to one pound of rice-bran, is :—

	Rs.	c.
1 oz. "Meta" at 17 cents	0	17
2 lb. rice bran at 2 cents per lb.	0	4
120 "Meta" balls cost	0	21

193 balls (required for an acre) cost 34 cents.

"Meta" packets, each containing 50 briquettes (weighing $7\frac{1}{2}$ oz.) can be purchased from most fertilizer firms at a cost of Re. 1·25 per packet.

ACKNOWLEDGMENT

The preparation of "Meta-Bran" baits described in the above notes was done in accordance with the suggestions of F. Beeley published in *The Journal of the Rubber Research Institute of Malaya*, 1938, Vol. 8, pp. 131–139.

SUMMARY OF LEGISLATION OR OTHER GOVERNMENTAL ACTION ON SOIL CONSERVATION IN VARIOUS COUNTRIES

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THIS summary of the legislation in force or other governmental action taken in various countries on the question of soil conservation was prepared at the express desire of the authorities, as it is considered that all agriculturists and those responsible for land policy in Ceylon should be acquainted with what is being done elsewhere on this problem of important national concern. A briefer summary was previously submitted to the Board of Agriculture by the Soil Conservation Officer. The material for this survey was obtained from various sources. In the case of the United States of America, Union of S. Africa, Malta, Straits Settlements, the Dutch East Indies and New South Wales, copies of legislation and other useful information were received by this Department direct from the countries concerned. Most of the other information was either furnished by the Imperial Bureau of Soil Science or extracted from the valuable publication of the Imperial Bureaux of Soil Science and Pastures and Forage Crops entitled *Erosion and Soil Conservation* by G. V. Jacks and R. O. Whyte. The Imperial Forestry Report Paper No. 14, *A Report on a World Tour for the Study of Soil Erosion Control Methods* by A. Grasovsky was also helpful. Occasional reference was also made to Government publications and other works bearing on the subject, *e. g.*, Memoranda of the Governments of Uganda, Kenya and Tanganyika on Soil Erosion; C. Longabardi's *Land Reclamation in Italy; Soils and Men, the U. S. A. Department of Agriculture Yearbook, 1939.*

While it would have been convenient for the purpose of this summary to have taken the countries in strict alphabetical order, it is considered preferable to make an exception with the United States of America where legislation and governmental activity on soil erosion have perhaps made the greatest advance and to deal with that country first.

UNITED STATES OF AMERICA

In April, 1935, the Congress of the U. S. A. passed an Act "To provide for the protection of land resources against soil erosion, and for other purposes." Under this Act a soil conservation service was created in the Department of Agriculture to conduct a comprehensive national programme for the control and prevention of soil erosion. This service was the outgrowth of the soil erosion service established in October, 1933, under the Department of the Interior. The Act, among other provisions, authorizes the Secretary of Agriculture :—

"(1) to conduct surveys, investigations and research relating to the character of soil erosion and the preventive measures needed, to publish the results of such surveys, investigations, &c., to disseminate information concerning such methods, and to conduct demonstrational projects in areas subject to erosion by wind and water ; and

(2) to co-operate or enter into agreements with, or to furnish financial or other aid to any agency, governmental or otherwise, or any person, subject to such conditions as he may deem necessary, for the purposes of this act."

The Soil Conservation Service exercises the powers conferred on the Secretary of Agriculture by the Act.

An amendment to this Act was passed in February, 1936, "to promote the conservation and profitable use of agricultural land resources by temporary Federal aid to farmers and by providing for a permanent policy of Federal aid to states for such purposes." By this amending Act, the purposes of the previous act were extended to include among others : (1) the preservation and improvement of soil fertility, (2) the promotion of the economic use and conservation of land, (3) the diminution of exploitation and wasteful and unscientific use of national soil resources, (4) the protection of rivers and harbours against the results of soil erosion.

Because of the great need for state legislation to carry out effectively the Federal programme, Congress, by this amending Act, authorized the Secretary of Agriculture to require the adoption of suitable state legislation as a condition of Federal money being spent in any state for erosion-control work. Accordingly, a Standard State Soil Conservation Districts Law was framed by the Department of Agriculture and representatives of a number of the states. In February, 1937, the U. S. President recommended to the 48 State Governors the submission of this standard law to their legislatures. Of these, 25 states adopted legislation on the lines of the standard Act and a number of others adopted modified statutes.

The standard Act provides a procedure by which "Soil Conservation Districts" may be organized and defines their powers. A State Soil Conservation Committee, composed of heads of the Departments of State concerned, is established, which has the power to define the boundaries of each district, to encourage the organization of districts, to co-ordinate the several district programmes, &c.

The procedure for organizing a district is as follows:—Twenty-five landowners may petition the state committee to establish a district. The committee is required to hold a public hearing on the petition and, if satisfied, to define the boundaries of the proposed district, and then to conduct a referendum on the petition. A district is established only if a majority of the votes is cast in favour of it.

Each district is an independent unit and is not subject to the control of the state committee. It is to be governed by a board of five supervisors two of whom are to be appointed by the committee and three to be elected by the land occupiers of the district. Each district has the power (1) to establish and administer erosion-control projects and preventive measures, including financial and other assistance to farmers, (2) to prescribe land-use regulations in the interest of the prevention and control of erosion, such regulations to be first submitted to local referendum and, if approved in the referendum, to have the force of law within the district. A Board of Adjustment is to be established in any district that adopts land-use regulations to which appeals can be made against the observance of these regulations by any land occupier. Decisions of the Board of Adjustment are subjected to review in the local courts.

Funds to finance the operations of the districts come from two sources: (1) direct appropriations out of the State Treasury, (2) grants-in-aid made to the Soil Conservation Service either through the state committee or direct. By June, 1938, 59 soil conservation districts were organized in 16 states. As the Editorial in *The Tropical Agriculturist* of July, 1938, states, this Standard Soil Conservation Act offers the fullest scope possible for "democracy in land use" and is well worth a trial locally.

AUSTRALIA

In *S. Australia* and *Western Australia* where sand drift is an acute problem, Sand Drift Acts have been in operation for a number of years, in order to protect roads, railways and private property.

In *New South Wales*, as recently as October, 1938, a Soil Conservation Act was passed to make provision for the conservation of soil resources and for the mitigation of erosion. A

Soil Conservation Service was created by this act to carry out investigational, propaganda, and "project" work on soil conservation. Provision is made for funds to be advanced to owners or occupiers of land for adopting measures against soil erosion. In areas of "erosion hazard," as defined by the act, action has to be taken against erosion within the area either by the private party concerned or by Government, if the former neglects to do so, in which case costs are recovered from the owner. Appeal against the orders of Government may be made to the Land and Valuation Court.

Catchment areas may be declared "proclaimed works" and as such are protected against damage or interference by private parties. Petitions of inquiry from owners of such lands will be inquired into by the Catchment Areas Protection Board. The Minister is empowered to utilize Government funds to carry out necessary works in such area, or, in certain circumstances, to request the owner to pay or contribute towards their cost. The owner may appeal to the Land and Valuation Court against payment.

The Act provides for the establishment of one or more advisory committees to consider matters relating to soil conservation or erosion-mitigation or any other purpose contemplated by the act. Provision is also made for the alteration of the clauses of certain land leases when the compliance of these would tend to cause erosion on any land.

The Governor is empowered under the Act to prohibit or regulate the destruction of, or interference with, timber or scrub on any lands held under any form of lease or licence from the Crown, or the lighting of fires in any catchment or erosion-hazard area.

BRITISH SOMALILAND

An ordinance entitled "The Preservation of Grazing Areas and Water Ordinance" was enacted in 1936. The District or Assistant District Officer of any district may, in consultation with the Agricultural and Veterinary Officer, and with the approval of the Governor, prohibit grazing, temporarily, in any area where it is deemed desirable. Any stock found in any of the prescribed areas will be impounded till a fine is paid for it by the owner, and, if the fine is not paid, confiscated.

CANADA

The Prairie Farm Rehabilitation Act was passed in 1935 to provide for the rehabilitation of drought and soil-drifting areas in certain provinces. Amendments to the Act passed in 1937 included provision for the establishment of one or more advisory committees. The following were established in 1937: (1) The Prairie Farm Rehabilitation Committee, (2) The

Water Development Committee, (3) The Land Utilization Committee. The functions of the committees are to consider and advise the Minister of Agriculture "as to the best methods to secure the rehabilitation of drought and soil-drifting areas, and to develop and promote within these areas systems of farm practice, tree culture, water supply, land utilization and land settlement that will afford greater economic security."

Expenditure is provided for by Government for the purposes of the act. In 1937-1938, this amounted to two million dollars.

THE DUTCH EAST INDIES

Laws pertaining to the general protection of the soil concern such lands that are alienated to peasants for agricultural purposes. Regulations to suit local circumstances are in force to ensure that such lands are cleared and opened up judiciously. The section relating to the protection of the soil is as follows :— "On sloping land, if there be danger of the cultivated areas being washed away, cultivation should be carried out in terraces and under such conditions as local circumstances require." In the case of lands which are transferred on a specific title (tenancy, building right, leases, &c.), tenants are required to preserve a vegetal covering with a view to protecting, if need be, wells or river banks against erosion. In certain cases, a general protection clause is added.

An ordinance was passed in 1925 for the protection of forest growth around wells and along rivers and rivulets. Where such forest growth does not exist, the tenants cannot oppose the planting up of forest by the authorities.

The general protection of the soil against erosion has not as yet been provided for in the ordinance. In the meanwhile, in the tenancy acts and in all other cases when local circumstances appear to require it, clauses are inserted whereby the tenant has to protect against erosion such areas as are indicated by the forest officers, according to the latter's instructions. Failing compliance, the whole or part of the land may be forfeited without any compensation.

FRANCE

Between 1861 and 1935 the French Administration of Waters and Forests has re-forested approximately 1,200,000 acres at a cost of over 300 million francs of which nearly a fifth has been spent in corrective works. A number of laws permit the forestry administration to ensure that private interests do not obstruct such work. The problem of stabilizing sand dunes along 720 miles of French coast is also undertaken by the forestry service.

ITALY

Technical and legislative measures adopted against soil erosion form part of the Mussolini Integral Land Reclamation Act which came into operation in Italy in 1929. Land reclamation is in the immediate charge of a special Under Secretary of State for Reclamation under the Ministry of Agriculture and Forests. A distinction is made between land reclamation and land improvement works. The latter are carried out on behalf of one or more farms and independently of a general land reclamation plan. Land improvement "Consortia" or associations of landowners are formed for the execution, upkeep and management of land improvements. The cost of such work is met by the State and by the landowners under specified terms. The reconditioning of mountain land is carried out exclusively by the forest service.

JAPAN

In 1897 a Forestry Act was passed which made torrent regulations compulsory throughout the Japanese Empire. This act was apparently amended in 1926. Article 14 of the Act provides for the protection of forests for the following purposes among others: to prevent denudation of the soil; to prevent sand-shifting; to provide protection against the devastation of floods, winds and tides; to ensure a constant source of water supply, &c.

Article 26 provides that without the permission of a local Governor no person may in a protected area cut or damage trees, or bamboos, reclaim land, collect or dig out soil, turf, bogwood, roots of trees or of grasses, or graze livestock. Control measures are, if necessary, enforced on private land, the State or local authorities undertaking five-sixths of the cost.

River training operations are carried out by the Public Works Department and the reafforestation of denuded hillsides by the Forest Department.

KENYA

In Kenya the Fire Prevention Ordinance which applies to all parts of the country and all sections of the community, prohibits the unauthorized burning of grass and trees. In native areas, provision is made for the prevention of soil erosion by a recent amendment of the Native Authorities Ordinance. Control of grazing in these areas has been effected by certain rules under the Crop Production and Livestock Ordinance, 1926. A soil conservation service under the Department of Agriculture has been formed. A draft Land and Water Preservation Bill is at present under consideration. All forest reserves are protected by rules under the Forests Ordinance.

MALTA

In Malta, soil is so valuable that its artificial removal from building sites to areas suitable for agriculture is made compulsory by law.

An ordinance cited as the "Fertile Soil Preservation Ordinance" was passed in 1935 to provide for the preservation of fertile soil. "Fertile soil" means soil which is, in the opinion of the Superintendent of Agriculture, necessary or adaptable for agricultural purposes. Under the ordinance no owner could erect any building on any site without first removing the fertile soil or a part thereof as directed by the Superintendent for utilization in connexion with agriculture. Penalties are imposed for the non-compliance of the provisions of the ordinance. Amendments to it were passed in 1936, one of which permits an appeal to the Governor from the decision of the Director of Agriculture in regard to certain clauses of the act.

NIGERIA

No legislation is in force except the prohibition of grazing in certain areas in which reafforestation and soil conservation measures are being carried out by the Forest Department.

NYASALAND

The legislation in force is embodied in the Forest Laws and Rules. There is usually a clause in the lease, when land is taken up by European farmers, for the replanting of a certain proportion with trees. The prohibition of the destruction of natural vegetation and cultivation of steep slopes was recommended by a committee of the Board of Agriculture as coming within the sphere of rule 5 which reads: "Any Forest Officer or Administrative Officer may at his discretion forbid the felling, cutting and removal of forest produce on the tops and slopes of hills and mountains." A Government Circular, No. 3 of 1936, recommends the following among other measures for the improvement of agriculture and control in the use of the land:—

(1) Soil conservation: by terracing, draining, contour planting and bunding.
(2) Protection of major catchment areas and watersheds by means of forest reserves.
(3) Preservation of natural vegetation on the poorer soils of the country.
(4) Protection of stream-banks and steep hill-slopes under powers of the Forest Laws.
(5) Preservation of belts of forest and natural vegetation on the better lands, to form windbreaks.
(6) The control of bush fires.

RHODESIA

In 1932, a soil erosion committee stressed the need for national action on soil erosion and recommended the establishment of district soil conservation boards under a Central Soil Conservation Advisory Council. Such councils and boards have accordingly been formed in North and South Rhodesia, and on these the farming community is represented. A Soil Conservation Act is under consideration. Financial advances are given on easy terms to farmers to enable them to adopt soil conservation measures, and technical assistance and planting material for use against erosion have been supplied free of cost by the Department of Agriculture. A Soil Conservation Officer is employed by the Native Department to carry out anti-erosion measures in the native areas.

UNION OF SOUTH AFRICA

While legislation exists in the different provinces of the Union in regard to veld burning, afforestation, &c., no legislation has as yet been introduced for combating soil erosion. The Government, however, encourages landowners to prevent erosion by subsidizing the construction of dams, contour banks, weirs and other anti-soil erosion works. Local soil erosion committees consisting of the Magistrate and two farmers appointed by the Agricultural Department have been formed to deal with all applications for assistance, to inspect land and to arrange for technical advice where necessary. Five Government schemes of assistance are available to farmers. Prior approval of the Department of Agriculture to the proposed scheme is required in every case before any subsidy could be granted. The schemes are as follows :—

Scheme A.—A bonus of 33⅓ per cent. is paid on the final evaluation of works completed by the applicant, at his own expense, to the satisfaction of the Department. The maximum amount payable on one farm is £166.

Scheme B.—A loan of not more than £350 is granted to a registered landowner. A subsidy of 25 per cent. on the final evaluation is also paid.

Scheme C.—The State meets seven-eighths of the wages of unemployed European labourers engaged in soil conservation work approved by the Department.

Scheme D.—A loan without interest up to £50 is granted for the purchase of materials, implements, &c.

Scheme E.—A bonus of 25 per cent. may be paid on the cost of fencing material used for fencing-in trees or shrubs planted for controlling soil erosion. The maximum bonus is £62.

STRAITS SETTLEMENTS

An ordinance was passed in December, 1937, entitled "The Hill Lands Ordinance," the object of which is "to restrain and prevent the use and cultivation of hilly land in a manner likely to endanger health or property." Under the ordinance, no person can cultivate any hill-land with "short-term crops" such as annual crops, pineapples, bananas, derris, except under permit, and then only within the garden of a house. No hill-land can be cleared or trees, plants, undergrowth, weeds, grass or vegetation removed or destroyed on such land except by permit for cultivation with crops other than short-term crops. A person who has been refused a permit has the right of appeal to the Governor in Council. The Governor has the power to direct that any hill-land shall be acquired for the purpose of preventing soil erosion whenever it is deemed desirable to do so. Contravention of the clauses of the ordinance renders the party liable to a fine or imprisonment or both.

TANGANYIKA

There is no general legislation in the Territory for the prevention of soil erosion, but preliminary consideration has been given to the enactment of an ordinance designed to protect public lands in the neighbourhood of railways and highways. Certain local measures, comprised within Native Authority and Cultivation rules are, however, in force. Such, for example, are the following :—

(1) No person shall cut trees or shrubs growing on hill tops.
(2) Before any individual may plant coffee, the land has to be prepared and approved shade provided to the satisfaction of the District Agricultural Officer or his nominee. In exercise of the rights conferred by the Native Authority Ordinance, all native authorities were authorized by the Governor in 1937 to issue orders "for the purpose of requiring the adoption of anti-erosion measures."

Some of the measures which may be prescribed by the native authorities are as follows :—

(1) Where cultivation takes place on ridges, the latter must be made on the contour principle, *i.e.*, across the slope of the hillside.
(2) Contour ridges by means of stone hedges or other suitable material should be constructed at suitable intervals, if cultivation is not done on ridges.
(3) Terracing.
(4) Storm water drains, ditches or pits.
(5) Tree planting to stop erosion by wind.

In certain districts the grazing of stock is prohibited in prescribed areas. In other districts the planting of crops, *e.g.*, coffee, or cutting of trees is forbidden in areas bordering rivers, springs, &c.

Any person contravening any of the provisions of the rules is liable to a fine or even imprisonment.

UGANDA

No soil erosion legislation is in force. A Government Agricultural Survey Committee recommended that special efforts be made with Government funds to adopt effective anti-erosion measures in specified areas. The work will be followed up with soil conservation propaganda among farmers.

2——J. N. 82595 (3/39)

THE ALL-CEYLON CATTLE SHOW OF 1939

ST. ELMO WIJEYEKOON

THE display of cattle at the show organized by the Cattle Breeders' Association of Ceylon on March 10 and 11, 1939, on the Ceylon Turf Club Grounds, came as a pleasant surprise to many people, and the large number and quality of the stock the country possesses were unexpectedly discovered.

In the opinion of those who had visited County and State cattle-shows in other countries, the main section of the show compared very favourably so far as the number, standard of the animals, site and management went.

Besides Ceylon cattle, that is, cattle of indigenous breed, there were breeds from India and the British Isles, and their crosses. The standard was creditably high, particularly that of the Government exhibits ; and the existing drought, which had adversely affected the strength of the entries, was not reflected in the exhibits themselves. This fact is a recommendation to our cattle breeders, and proves that the breeds encouraged are generally suited to this climate.

Owing to a lack of variety in the exhibits—caused by the absence of previous experience of shows—many of the classes did not fill and had to be grouped together. Hence there arose the difficult situation of dairy and draught cattle being judged together. This anomaly was noticeable more especially in the Indian cattle section, with the result that the draught varieties which out-did the dairy breeds in numbers captured the judge's eye, and the dairy breeds—chiefly the Sindhi—failed to secure a single first prize.

The only classes which filled satisfactorily were some of country-bred Indian and cross-bred classes, which by reason of their numbers presented the judges with no easy task. Another difficulty which arose during the judging of the pure-bred classes and necessitated such remarks as "Kangayam × Hissar," "heifer apparently not pure Sindhi," "remaining entries all cross-breds" in the judging books was the presence of animals of doubtful origin in these classes. This denotes that most breeders do not exercise sufficient care in their work ;

and that they fail to take steps to maintain the purity of breeds. A sure method would be to keep only one breed at each of their cattle-breeding centres.

There were 190 head of cattle at the show of which 77 were cross-breds. Indian cattle came second with 66 entries and Ceylon cattle took third place with 26 entries, while European and Australian pure-breds numbered 21.

THE EUROPEAN PURE-BREDS

In the pure-bred section, the best animals were found in the imported classes. Most of these belonged to the Department of Agriculture and were non-competitive exhibits. The country-bred pure animals were wanting both in quality and in numbers. This rather discouraging state of affairs may be explained thus :—

(1) The excessive demands of a climate of debilitation causes rapid deterioration of stamina and size. In the hands of the average breeder these deficiencies remain uncorrected for generations, or the strain dies off before it can make any useful contribution.

(2) The right breed from overseas for perpetuating its species in our climate has perhaps not been discovered yet. But with the breeds already under experiment, and the triple-purpose Red Poll given every chance, a useful conclusion should be in our hands before long.

(3) The prohibitive cost of importing fresh blood, and the comparatively poor return the private cattle-breeder derives, act as set-backs to individual enterprise.

Although imported cattle seem to have failed to enrich the country with pure climate-resisting stock, they have been used to advantage with Indian and local animals to provide hardy strains of cross-bred cattle for dairy and draught purposes.

THE GRAND CHAMPION A RED POLL

Queensland, in tropical Australia, provided the Red Poll cow acclaimed the best exhibit at the show. She is a worthy representative of an unsurpassed all-round breed.

The points which recommend the Red Poll are the following characteristics it possesses :—

1. Hardiness.
2. Strong foraging instincts.
3. Ability to withstand the most severe drought and other extremes of climate.
4. Docile and tractable nature and the absence of horns.
5. Good milk yields on the usual feeding rations, averaging over $6\frac{1}{2}$ gallons of milk per day.

6. Milk contains an average butter-fat content of 4 per cent.
7. Quick fattening qualities.
8. Aptitude for draught purposes.

Is the Red Poll the European breed of the future ?

AYRSHIRES FORM STRONG SECTION

The Ayrshires on show, with a single exception, were Government exhibits, and were numerically the strongest of the dairy cattle in the European and Australian cattle section. The exhibits were shown in very good condition and attracted much attention. The most typical example of a milking cow, the Ayrshire vies with the Kerry for the reputation of being able to yield a good return of dairy produce on poor land and inferior food. Cows of this breed tend to put on too much flesh, which brings about a corresponding reduction in milking powers. The best preventive for tendencies of this nature is to arrange that heifers shall calve after the second year instead of after the third—the ordinary calving time of the breed. Then their milking powers are developed at the expense of the tendency to produce flesh.

FRIESIAN BULLS SHOW WELL

The Friesians—all bulls except one—made a fairly good show. While some of the exhibits were of a high quality, others disclosed traces of the results of crossing. These features were highly undesirable in the pure-bred classes. The Champion Friesian—an imported bull, 12 years of age—was a particularly fine animal of beautiful conformation and true to type : a good bull for the production of progeny with milking qualities. From the utility point of view this breed is the most favoured for its capacity for heavy milk yields ; but the quality of the milk—at least as regards butter-fat—is often poor. In Holland, the average butter-fat content is reported to be below 3·5 per cent. ; but the butter-fat content—as in other breeds—is capable of being raised by careful selection. Essentially a dairy breed, the Friesian has been shown by certain Scottish breeders to be able to take on beef-producing characteristics as well. The Friesian is the breed for good conditions. With our poor pastures and frequent droughts, preference should always be given to less exacting breeds, for the Friesian will certainly not answer the call for an all-rounder in any weather.

THE KERRIES IMPRESS

This Irish Cottar's breed is the "thorough-bred of Irish Cattle," and specimens were exhibited in fine condition by the Department of Agriculture. This breed was specially imported for experiments with black cattle of indigenous breed.

Cows of this breed give milk yields of about 2½ gallons per day with a butter-fat content varying from 4 to 5 per cent. In general outline, the Kerry has much in common with the Jersey or, for a matter of that, with the Ayrshire, though in size it is smaller than either. Its spare form indicates its superiority in milking rather than in beef qualities. This breed from Ireland crosses remarkably well with other breeds, and can exist on sparse conditions.

THE INDIANS

The second highest number of entries was recorded in the Indian cattle section which was composed of the following breeds—Hissar, Nellore, Sindhi, Kangayam, Gujerati and Montgomery.

The draught cattle in this section were a sturdy lot and did very well in annexing most of the prizes. The best country-bred Indian bull was a Nellore of outstanding quality. That all is well with the larger-sized draught Indian cattle in Ceylon is evident. But a further improvement in this direction can well be anticipated by the introduction of the Kangayam—a breed of powerful draught-cattle of moderate size. The only animals of this breed on show were those exhibited by the Department of Agriculture. These animals are constitutionally very sound, economical to maintain, and have been found to continue to last from 10 to 12 years in full working fettle. The Indian dairy-breeds were strongly represented by the Sindhi and Montgomery breeds. The best exhibits of the former, and the only exhibits of the latter, were those sent in by Government. Red Sindhi cattle are, comparatively speaking, small, compact animals—perhaps one of the reasons for their having missed the judge's eye in the open Indian classes. They are the most efficient milch-cattle of India; and are greatly in demand for milk production in the tropics. They produce excellent results when crossed with European breeds. The Montgomery, or Sahiwal, exhibited solely by Government is another future breed of Indian milch-cattle. The fact that they can exist in dry areas with poor pasture makes them well suited to this country. The bullock of this breed is useful for slow work, but, though not essentially a draught animal, it is reputed to make good as a fattener.

CATTLE OF INDIGENOUS BREED

In this section there were some good specimens of Ceylon cattle. Of considerable assistance to the judges were the fine specimens from the Government experimental station for indigenous cattle in the South. Here again there were some exhibits showing traits of crossing, and the process of elimination took up too much of the judges' time. For purposes of

improving the breed, the judicious infusion of Kerry blood seems highly desirable. But whatever methods are employed to grade up the Ceylon breed of cattle, the type—so ideally suited to rural requirements—must not suffer. All that the Kerry means to the Irish Cottar, the indigenous breed must mean to the Ceylon peasant. The champion exhibit in this section was a bull—" a very typical specimen of good colour, and very good head."

EXCELLENT SHOW OF CROSS-BREDS

The cross-breds turned up in full force, and made their section the most popular with 77 entries. There were such crosses as Sindhi, Ayrshire, Friesian-Sindhi, Poll-Ayrshire, but it is difficult to say which is the most popular, as many exhibitors were unable to state the exact details of the crosses. From inspection, one fact was evident—that the Sindhi and Ayrshire had done their bit in providing most of the animals in these classes.

Should this type of cross seem to suffer from the ill-effects of climate by over-much pure European qualities, a sure remedy is the infusion of new Sindhi blood, which will help in the grading up of stock while preserving the milking qualities.

This show has been a definite stimulus to cattle-breeding. Our aims to breed more and better cattle can be achieved only if this new interest leads to a more scientific idea of the business. In place of the more or less haphazard cattle-owning, strict attention should be paid to herd registering and recording, scientific feeding which involves pasture management and conservation of fodder, and the preparation for drought. The serious set-backs that so often hinder the progress of cattle-breeding are not occasioned by Nature's varying moods but by man's remissness.

(The opinions expressed in the above article are those of the author, and the Editor does not necessarily agree in all points.

For example, the statement that Red Polls as a breed average over 6½ gallons of milk per day would appear to require modification. A few selected cows can average over 6½ gallons under special conditions, but the general breed average is very much lower.

Ayrshire breeders would probably take exception to the statement that cows of this breed tend to put on too much fat.

The usual calving age for Ayrshire cattle in Scotland is between 2 years and 3 months and 2 years and 6 months.

The breeders of Sahiwal cattle in India would probably contest the claim that the Sindhis are the most efficient milch cattle in India.

There are other suggestions in the note to which the Editor cannot subscribe.—Ed. T.A.)

THE FERTILIZATION OF CITRUS TREES*

AS is the case with other varieties of plants, the substances that citrus trees need to carry on their existence are air, water, phosphoric acid, potash, lime, and to a lesser degree such minerals as magnesium, iron, sulphur, manganese, zinc, copper, &c.

Air is, of course, plentiful and free to all, but it is the only requisite of plant life that is. Water is a most important factor in the development of the plant, the greater portion of the living plant consisting of water. Water, moreover, by dissolving the plant foods contained in the soil, reduces these to a condition in which they can be easily absorbed by the roots of the plants. The action of water in making available large quantities of plant food is the chief reason for the increased fertility shown by soils in arid areas when they are irrigated.

Water, then, is the first requisite that must be added to the soil to promote plant growth, and as citrus trees require more moisture than do most other varieties of fruit trees, the first essential to successful citrus culture is an ample rainfall, or where this does not exist, then the land must be supplied with sufficient water by means of irrigation.

Of the various mineral ingredients contained in the soil phosphoric acid, potash, nitrogen, and lime are the ones taken up in the greatest quantities by the various plant varieties, including citrus trees, and as the consequent removal of these plant foods from the land through cropping will, in time, lead to the impoverishment of the soil, these substances must be replaced if the land is to remain in a fertile condition.

HUMUS

Besides their mineral ingredients practically all soils contain a greater or less amount of decayed organic matter, or humus, which is especially the case with virgin lands, which in their natural state are covered with forest, shrubs, or grasses. Humus, consiting of the elements, drawn from the air and soil, and having formed the substance of organic beings, is naturally rich in the ingredients required for plant life. A soil well supplied with humus is therefore a fertile one, and few of the higher classes of plants will thrive if humus is deficient in the soil.

Humus, moreover, is the home of the nitrifying soil bacteria. These bacteria have the property of taking up the nitrogen from the air that penetrates the soil into their own bodies, and thereby increasing the nitrate content of the soil.

The desirability of having a good supply of humus in the soil of the citrus orchard is therefore apparent.

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* A Paper read at the Conference of River Murray Branches of the Agricultural Bureau, held at Berri on June 16, 1938.—By F. R. Arndt, Horticultural Adviser for the Upper Murray District of South Australia, in the *Department of Agriculture, South Australia, Bulletin* No. 335.

MANURIAL PRACTICES IN PAST YEARS

For many years the fertilization of the citrus grove was, to a great extent, a matter of guesswork, and a variety of manurial practices was practised by citrus growers. When considerable quantities of organic matter—generally applied in the form of stable manure—were given to the trees, fairly good results were generally obtained ; but the application of phosphatic or potassic fertilizers by themselves, or with small quantities of nitrogen very often gave only indifferent results.

In later years growers in applying larger quantities of nitrogen—often together with heavier dressings of other chemical fertilizers as well—generally found that the trees so treated made more vigorous growth and bore better crops than formerly, but were often at a loss as to which of the fertilizers the beneficial results so obtained were chiefly due.

It was not until the subject of the fertilization of citrus was thoroughly investigated at scientific research stations, chiefly in the United States of America and in Australia that the great value of nitrogen as a citrus fertilizer was definitely established, and the manuring of citrus trees placed on a sound basis.

CITRUS FERTILIZER TRIALS AT THE STATE EXPERIMENTAL ORCHARD AT BERRI

To test the value of various kinds of fertilizers in relation to citrus trees a series of manurial experiments was commenced at the Berri Experimental Orchard in 1920 with trees planted in 1911, and these trials, with some modifications, are still being continued.

These experiments have definitely demonstrated the overwhelming importance of nitrogen as a fertilizer for citrus trees, either by itself, or in conjunction with other fertilizers.

The land upon which the trees utilized in these experiments are planted consists of a light, deep, red sandy loam, typical of much of the soils of the Murray upland slopes, and has been classed as " Murray Sand " in the C.S. and I.R. Soil Survey of the Berri area.

The trees given over to these experiments are, with the exception of some off-type navels situated in the superphosphate fertilizer plot, of the Washington navel variety, and are planted at the rate of 99 to the acre.

The fertilizers were applied in two dressings, half quantity in spring and the other half in late summer. The first records in regard to yields were taken in 1921.

In the following tables the average annual acreage yields of the various fertilizer plots have been worked out from the data supplied by the manager of the Berri Experimental Orchard, Mr. O. E. Halliday, on the basis of 48 lb. to 1 bushel of fruit.

The results herein given have been compiled from the records taken up to the end of the 1937 season, and include a considerable amount of data that has not been previously published.

Each separate test has been confined to one row, or part of a row of orange trees, the rows running in the direction that the trees are watered.

SULPHATE OF AMMONIA FERTILIZER TESTS

The following are the records of the sulphate of ammonia fertilizer tests for the past 17 years :—

Sulphate of Ammonia Tests.

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre.	Average Annual Yield in Bushels per Acre, 48 lb. = 1 Bushel	
			Years 1921–1929, inclusive.	Years 1921–1937 inclusive.
		cwt.		
3	16	1	69	137
4	16	2	103	138
5	16	3	192	228
6	16	4½	218	264
7	17	5	212	248
8	17	2½	186	206
9	17	No fertilizer	60	39

From the above figures it will be seen that with the exception of the no fertilizer plot, which showed a decline, all of the other sections increased their average annual production over the whole of the 17-year period of the experiment compared to that of the first nine years, which was, in great measure, probably due to the trees attaining greater age.

In these experiments no cover crops were grown among the trees or any organic fertilizers or other humus forming materials brought on to the land.

SULPHATE OF POTASH TEST

The records of the sulphate of potash tests for the nine years, 1921 to 1929 inclusive, are as follows :—

Sulphate of Potash Fertilizer Tests.

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre.	Average Annual Yield per Acre in Bushels, 48 lb. = 1 Bushel, Years 1921–1929, inclusive.
		cwt.	
10	16	1	46
11	17	2	101
12	16	3½	52
13	16	5	64
14	17	2½	32

It will be observed that there is a considerable difference in the production of the various tree rows, no doubt due to one or more of several factors, such as variations in soil conditions, situation or hereditary differences in the trees themselves, and the low average yields of rows 10 and 14 may, at least in part, be accounted for by the fact that the former is situated next to a " no manure " row, and to the latter being located alongside a row of almond trees.

In comparing the average annual acreage yields of the sulphate of ammonia and sulphate of potash plots with each other these show that those of the former are about two and three quarter times as great as those of the latter ; and even if Rows 10 and 14 are excluded from the calculations owing to their rather unfavourable situation, the average annual yield from the sulphate of

ammonia plot for the nine year period of the experiment is still more than twice that produced by the three remaining rows fertilized with sulphate of potash.

The exclusive use of potash had not been continued for more than a few years when there were indications that this fertilizer treatment was detrimental to the welfare of the trees. This became more and more apparent as time went on, the trees year by year decreasing in vigour, colour of foliage and productiveness.

At the end of nine years the health of the trees had declined to such an extent that the colour of their foliage had changed to a distinct yellowish shade, while such new growth as was made was weak and stunted.

The decline in the productivity of the trees during this period was likewise great, and had decreased to an average of 22 bushels per acre for the whole plot for the ninth year of the experiment.

The trees by this time had become so unthrifty that it was apparent that no further demonstration was needed to prove that potash by itself was unsuited for the successful culture of citrus trees (at least as far as conditions at the Berri Experimental Orchard were concerned) and it was decided to discontinue the experiments in that form, and by the addition of nitrogen to the fertilizer programme to carry out a new series of tests.

The six weakest of the trees, which were situated at the beginning of the irrigation runs, were excluded from these new series of experiments, as being too weak and stunted for further experimental work, but were still fertilized with potash, while another 21 trees were utilized in barrier rows. The remaining 55 trees were still given the same quantities of sulphate of potash as formerly, but were in addition supplied with nitrogenous fertilizers.

RESULTS OF TRIALS WITH MIXTURES OF POTASSIC AND NITROGENOUS FERTILIZERS

In the new trials each test row was divided into two portions, consisting of five and six trees each respectively, and each such section was fertilized either with 5 cwt. of sulphate of ammonia or with $7\frac{3}{4}$ cwt. of blood manure, besides receiving the same quantities of sulphate of potash as formerly.

These tests had not been in progress for more than a few years before a wonderful recovery was made by the trees, both in general health and in productiveness, and they soon attained the characteristics of normal, well-grown orange trees.

For the eight-year period that these new trials have now been in progress, the average annual acreage yields have been slightly better than those obtained in the sulphate of ammonia tests, while when compared with those secured when only potash was used, the records show an annual average acreage production almost four times as great.

The production records of the potash-nitrogen experiments are shown in the following table compared with the results obtained from the use of potash only.

Tests with Sulphate of Potash and Nitrogenous Fertilizers.

Row Number.	Number of Trees in Test.	Quantities of Fertilizers applied per Acre.	Average Annual Yield per Acre in Bushel Cases, 48 lb. = 1 Bushel. Mixed Fertilizers, Years 1930–1937.	Potash only, Years 1921–1929.
Part 10	5	1 cwt. sulphate of potash, 7¾ cwt. blood manure	77	46
Part 10	6	1 cwt. sulphate of potash, 5 cwt. sulphate of ammonia	177	46
Part 11	5	2 cwt. sulphate of potash, 7¾ cwt. blood manure	241	101
Part 11	6	2 cwt. sulphate of potash, 5 cwt. sulphate of ammonia	402	101
Part 12	5	3½ cwt. sulphate of potash, 7¾ cwt. blood manure	284	52
Part 12	6	3½ cwt. sulphate of potash, 5 cwt. sulphate of ammonia	238	52
Part 13	5	5 cwt. sulphate of potash, 7¾ cwt. blood manure	236	64
Part 13	6	5 cwt. sulphate of potash, 5 cwt. sulphate of ammonia	269	64
Part 14	5	2½ cwt. sulphate of potash, 7¾ cwt. blood manure	222	32
Part 14	6	2½ cwt. sulphate of potash, 5 cwt. sulphate of ammonia	168	32

TEST WITH SUPERPHOSPHATE

Another series of trials regarding the productivity of orange trees was carried out by applying various quantities of superphosphate to different rows of trees.

As previously mentioned the plot given over to these experiments comprises a considerable number of off-type navel trees, which, however, are fairly evenly distributed over the various tree rows with the exception of Row 8, which consists entirely of good type navels, and so has here been omitted from these records as not yielding a fair basis of comparison with the other trees.

The land occupied by these trees is, with the exception of Rows 7, 9 and 10, hardly first class citrus land, and this, combined with the fact that many of the trees are not of the true Washington navel type, probably accounts for their low production during the 8-year period that these experiments were in progress.

The following are the records of these fertilizer experiments for the years 1921 to 1928, inclusive :—

Superphosphate Tests (Strength of Fertilizer = 36% Superphosphate).

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre. cwt.	Average Annual Yield per Acre in Bushel Cases 48 lb. = 1 Bushel, Years 1921–1928, inclusive.
1	9	1½	33
2	9	3	16
3	10	4½	25
4	10	6	28
5	10	8	37
6	10	10	23
7	9	5	90
9	10	6	92
10	10	12	93

The above figures show an exceedingly low rate of production, even when allowance is made for the type of the trees and the nature of the soil, and seem clearly to indicate that the application of superphosphate by itself is a most unsatisfactory fertilizer programme to follow in the manuring of citrus trees.

As was the case with the trees that were fertilized exclusively with potash, the trees on this plot also decreased in vigour and the colour of their foliage yellowed as time went on, but not quite to the same extent as those treated with potash alone.

TESTS WITH SUPERPHOSPHATE AND NITROGENOUS FERTILIZERS

After these experiments had been carried on for eight years it was apparent that the unsuitability of superphosphate as a sole fertilizer for citrus trees had been amply demonstrated. The trials were accordingly discontinued in their original form, and in 1930 were modified to include sulphate of ammonia and stable manure in addition to superphosphate.

In these new experiments the Rows 2, 4, 6 and 10 were utilized for the fertilizer trials, and the intervening rows used as barrier rows. Each fertilizer row was divided into two sections, with a barrier tree separating the sections, and in addition to superphosphate were fertilized either with sulphate of ammonia or stable manure.

The results of these experiments compared with those of the same test rows when these were fertilized with superphosphate only, are as follows :—

TESTS WITH 36 PER CENT. SUPERPHOSPHATE, SULPHATE OF AMMONIA, AND STABLE MANURE

Row Number.	Number of Trees in Test.	Quantities of Fertilizers applied per Acre.	Average Annual Yield per Acre in Bushels, 48 lb. = 1 Bushel.	
			Mixed Fertilizers, Years 1930–1937.	Superphosphate only, Years 1921–1928.
Part 2 ..	3	.. 3 cwt. superphosphate, 15 tons stable manure	99	.. 16
Part 2*a* ..	4	.. 3 cwt. superphosphate, 5 cwt. sulphate of ammonia	175	.. 16
Part 4 ..	4	.. 6 cwt. superphosphate, 15 tons stable manure	328	.. 28
Part 4*a* ..	4	.. 6 cwt. superphosphate, 5 cwt. sulphate of ammonia	176	.. 28
Part 6 ..	3	.. 10 cwt. superphosphate, 15 tons stable manure	216	.. 23
Part 6*a* ..	4	.. 10 cwt. superphosphate, 5 cwt. sulphate of ammonia	283	.. 23
Part 10 ..	4	.. 12 cwt. superphosphate, 15 tons stable manure	390	.. 93
Part 10*a* ..	4	.. 12 cwt. superphosphate, 5 cwt. sulphate of ammonia	410	.. 93

Little further comment is necessary upon this series of experiments, as the figures speak for themselves. The results obtained by the application of either sulphate of ammonia or stable manure are most striking and show that the yields per row were thereby increased from more than four to twelve times of those obtained when only superphosphate was used.

NET RESULTS OF BERRI CITRUS FERTILIZER TESTS

The results obtained in the citrus fertilizer trials of the Berri Experimental Orchard clearly show that nitrogen is a major limiting factor in citrus production, and that the application of potash and superphosphate by themselves is quite insufficient to provide the trees with the requirements necessary for their successful development.

Bulky organic fertilizers have only been used in connection with the four test rows in the reconstructed superphosphate plot, where stable manure, in addition to superphosphate, was applied ; and for the 8-year period that these trials have now been going on the production of the trees under this test has been practically the same as those obtained from the adjacent test rows where sulphate of ammonia was used in conjunction with superphosphate.

There are indications, however, that on some of the fertilizer plots, which have now been under clean cultivation for over 20 years, the original supply of humus in the soil has greatly diminished, and that the trees would benefit by the addition of bulky organic fertilizers to the land.

CALIFORNIAN EXPERIMENTS

Extensive experiments in the fertilization of citrus trees have been carried on in California for a number of years on various experimental stations.

The results generally coincide with those obtained at Berri, but the experiments have been carried out on a much more extensive scale.

As at Berri, the Californian researches show that nitrogen is the limiting factor in citrus production, and that potassic and phosphatic fertilizers by themselves, or together, are of little use in promoting the productivity of citrus trees.

Considerable experimental work has also been done with organic fertilizers in bulky form, such as barnyard manure, lucerne-straw, or cover crops, and these have generally given better results than when only concentrated nitrogenous fertilizers have been used, but a mixture of these two kinds of fertilizers has been found to be the most effective with trees in full bearing.

The Californian researches indicate that citrus trees in full bearing under average conditions require from 2 to 3 lb. of nitrogen per tree per year, half of which should be supplied from bulky organic sources and the other half from chemical concentrates.

COVER CROPS

Whether the growing of cover crops among citrus trees is advisable or not is a matter that has often exercised the minds of many citrus growers.

With deciduous fruit trees and vines, which are dormant during winter, and which consequently take but little moisture from the soil at this time of the year, cover crops can be grown amongst these without causing them to suffer any ill effects from want of moisture ; but with citrus trees the case is different, as these require that the land should be kept fairly moist during this period to enable them to fill out their fruit and to replenish the moisture lost by transpiration through their foliage.

Owing to the dry climatic conditions generally prevailing in the Murray districts, cover crops cannot be successfully grown in a normal season, even among deciduous trees and vines, without an autumn or winter irrigation, but in the case of citrus trees more waterings than this are often necessary, which makes the growing of cover crops a more costly one.

There can be little doubt that among young trees the practice is a beneficial one, as the tree roots are not, as yet, in full possession of all of the land, and the cover crops consequently do not compete unduly with the trees for plant food and moisture.

With older trees, however, from 10 to 12 years of age and onwards, the case is different, as these require more moisture than younger trees to carry on their normal functions, and the growing of cover crops among them may, in the absence of heavy rains or frequent waterings, dry out the soil to such an extent as to detrimentally affect the health and vigour of the trees.

Other disadvantages in the growing of cover crops among full grown citrus trees include—the detrimental effect of excessive shade, which often prevents the satisfactory development of the crops, even when the soil is well supplied with moisture ; the inconvenience caused by the work necessary for the irrigation of the trees while the harvesting of the fruit is in progress ; and the damage that may be done to the crops by the pickers when moving around and between the trees during harvesting operations.

BULKY ORGANIC MANURES

Owing to the difficulties experienced in the growing of satisfactory cover crops the most effective way in which to supply full grown citrus trees with humus and other fertilizing substances from organic sources is by bringing bulky organic manures on to the land.

These may consist of various kinds of animal manures, and of materials of vegetable origin, such as lucerne, bean straw, wheaten straw, and of other products of plant life.

The manurial value of the different organic substances varies considerably, especially in nitrogenous content, and allowances must be made for this in the fertilization of the citrus grove.

From information supplied by Mr. C. S. Piper, Chemist of the Waite Agricultural Research Institute, several years ago, it appears that the nitrogen in one ton of air dry tops of the kinds of the leguminous plants here mentioned is as follows :—Beans, 80 lb. ; tares, 58 lb. ; peas, 54 lb. ; and lucerne, 53 lb. To express these amounts of nitrogen in terms of sulphate of ammonia, it is necessary to multiply by 5—sulphate of ammonia containing approximately 20 per cent. of nitrogen. Therefore the nitrogenous content of 1 ton of these dry plant substances is, in the case of beans, equal to 400 lb. of sulphate of ammonia ; tares, 290 lb. ; peas, 270 lb. ; and lucerne, 265 lb. of that fertilizer.

STABLE MANURE

The manurial value of stable manure, which is the fertilizer of bulky organic form most often applied to citrus trees, has been variously computed to contain from 8 to 15 lb. of nitrogen, 6 to 12 lb. of potash, and 6 to 7 lb. of phosphoric acid per ton, the differences in these fertilizing properties being partly due to the nature of the fodders that the animals have been fed on, and partly to the condition of the manure when used.

Stable manure is generally applied to the land in a partly rotted form, but in the process of storing, carting and spreading often dries out considerably, with the consequent loss of some of the nitrogen in the form of ammonia.

If the nitrogenous content of manure at the time of ploughing in be computed to be one-half one per cent., then one ton of stable manure will contain about 11 lb. of nitrogen, which is equivalent to almost ½ cwt. of sulphate of ammonia, and if 10 tons be applied per acre (which may be considered a serviceable dressing), then the land will be enriched with nitrogen equal to that supplied by about 5 cwt. of sulphate of ammonia.

In addition to its nitrogenous content, the application of 10 tons of stable manure of average quality will supply phosphoric acid roughly equal to that contained in about 3 cwt. of superphospate, and potash equal to about 1½ cwt. sulphate of potash. Besides its direct manurial value, stable manure, in common with other bulky organic fertilizers when applied to the land, promotes conditions favourable for the development of the nitrifying soil bacteria, and in addition has the property of improving the physical texture of the soil and increasing its water holding capacity.

BALANCED FERTILIZER PROGRAMME

As nitrogen is the chief limiting factor in citrus production it is the fertilizer that has first of all to be taken into account when the fertilization of the citrus grove is being considered.

Allowing for 100 trees to the acre (which may be considered the average planting in the irrigation areas), and that the minimum requirement of nitrogen is 2 lb. per annum per tree in full bearing, then if half of this is to be supplied from bulky organic sources and half from concentrates, this may be obtained by the application of 9 tons of stable manure and 4½ cwt. of sulphate of ammonia. If it is desired to increase the supply of nitrogen to 3 lb. per tree the quantities of the above fertilizers must be increased by 50 per cent., but this should only be necessary with very large trees.

Where such large quantities of stable manure or other organic substances are difficult or costly to obtain, the greater portion of the nitrogen required by the trees must be obtained from chemical concentrates; but organic matter should be applied to the land whenever possible to keep up the fertility of the soil and the health of the trees.

As the Berri fertilizer trials tend to show that the application of nitrogen with either potash or superphosphate has given better results than those obtained from the use of nitrogen alone, it is advisable that these latter fertilizers should also be used if organic manures are not freely applied, but heavy dressings should not be necessary, and the application of about 3 cwt. of superphosphate annually, and from 1 to 2 cwt. of sulphate of potash every second year should be sufficient on most plantations. The importance of phosphoric acid and potash is at present under investigation.

For young trees not in bearing heavy applications of fertilizer should not be needed. Cover crops of peas or beans should supply most of the fertilizer they require, but light dressings of sulphate of ammonia at the rate of 1 to 2 cwt. per

acre may also be helpful at times. Where cover crops are not grown moderate dressings of stable manure or other organic matter should be applied to the land.

TIME AND METHODS OF APPLICATION

The best time to apply the greater portion of the fertilizer required for citrus trees is in late winter or early spring before the trees have commenced their new season's growth, so that it may be readily available for the production of new foliage and help in the flowering and setting of the fruit.

Stable, or other bulky manures, should be applied during the winter and ploughed in, so that they rot very quickly and their plant foods become available to the trees during spring and early summer. Such manures can either be distributed broadcast over the whole of the land before it is ploughed, or spread in one or more deep furrows along each tree row and then ploughed in. Compared with the one furrow method of application, broadcasting will result in a more even distribution of the roots of the trees, promote bacterial activity, and improve the texture of the soil, over a wider area, but where the manure is put into two or more furrows more uniform soil conditions will be established than when only one is used, and the tree roots will consequently not be so closely crowded together in obtaining their food supply.

The superphosphate, potash, and about half of the nitrogen concentrates should be applied just prior to or after the first irrigation in spring. The remainder of the nitrogen concentrates may be used in two equal dressings during December and February, or may be utilized by being applied in smaller quantities at each irrigation.

The concentrated fertilizers may be applied either by broadcasting and ploughing under, by scattering along the bottom of plough furrows, or by drilling with an orchard manure sower.

Broadcasting, although theoretically the best way to apply fertilizers, as every portion of the orchard is thereby evenly supplied, is in practice not always the most satisfactory method, for unless the land is very deeply ploughed and the manure turned well under, much of it will be placed too shallow for the roots to readily come in contact with it. This is especially the case with superphosphate, which does not leach very deeply nor spread very far from where it has been placed, even under irrigation conditions, and should consequently be put down deeply into the soil.

Concentrated fertilizers, to give best results, should act fairly quickly, and in this respect are different from bulky organic manures, which render available their fertilizing properties much more slowly ; therefore if they are distributed by means of either manure sowers or by being placed at the bottom of plough furrows, they are put more deeply into the soil and so become more quickly available to the trees.

THE COLD STORAGE OF FRUITS AND VEGETABLES*

I. INTRODUCTION

THE term " cold storage " is applied to methods of storage at low temperatures generally produced and maintained by mechanical means. One of the earliest known methods of storage of perishable foodstuff was to keep it in a cave or cellar. Natural ice where it was available was also used for storing purposes. Modern mechanical refrigeration is a great improvement over such primitive methods and can be used in all countries under all conditions.

The Royal Commission on Agriculture in India made the following remarks in their Report (1928) :—

> " Cold storage is, in other countries, playing such a remarkable part in the marketing of goods, both for export and for internal consumption, with results so generally profitable to the private enterprise undertaking the arrangements as well as to the farmer, that we do not doubt that sooner or later there will be a similar development in India. We trust that those concerned will keep abreast with the research on the subject of cold storage which is being carried out in other countries, and will, when the time comes, prosecute in India any investigations required to adapt modern practice to local conditions." (Page 408.)

The Imperial Council of Agricultural Research at an early stage of its existence took up this question and decided to locate its first cold storage research station at the Ganeshkhind Fruit Experiment Station, Kirkee, near Poona, in the Bombay Presidency. The Bombay Government had already in 1930 put up preliminary proposals for such work and was accordingly invited to put up further proposals which after being duly examined by the appropriate Sub-Committee of the Advisory Board of the Council, by the Advisory Board itself and by the Governing Body, were sanctioned as from March, 1934, for a period of three years at a cost of Rs. 90,154. The scheme was extended for a further period of three years at an additional cost of Rs. 50,188.

II. THE COLD STORAGE PLANT AT THE GANESHKHIND FRUIT EXPERIMENT STATION

Acknowledgments are due for the great assistance received from staff of the Low Temperature Research Station, Cambridge, in planning cold storage equipment. The workers in this institution gave Dr. G. S. Cheema, who had been given an Empire Marketing Board Scholarship to study cold storage methods, every possible assistance.

* By G. S. Cheema, D.Sc., I.A.S., and D. V. Karmarkar, M.Sc., Ph.D., A.I.I.Sc., of the Cold Storage Research Scheme, Kirkee, in *The Imperial Council of Agricultural Research, India, Miscellaneous Bulletin* No. 23.

The authors are thankful to Dr. W. Burns for not only suggesting the lines on which this paper should be written but for also making many alterations and additions in the original manuscript so as to make it suitable for publication in its present form.

The refrigerating machinery was supplied by Messrs. J. & E. Hall, Ltd., of Dartford, Kent, England, and the construction work was supervised by the Agricultural Engineer to the Government of Bombay Presidency. The refrigerating plant consists of an ammonia compressor (5 H.P.) which is run by electric power. The evaporator coils cool down the brine in the brine tank which is circulated in the different chambers. There are seven chambers, each 10 × 9 × 8 feet, and, in addition, there is a sufficiently wide (3 feet) air-lock corridor in front of the chambers. Cork slabs have been used as insulation in the construction of the walls, the floor and the ceiling of the cold chambers. Each chamber is fitted on one side with a wooden diaphragm which shields the cooling pipes carrying the cold brine. At the upper end of the diaphragm there is fitted an electrical fan (1 H.P.) of the propeller type, for air circulation. A thermograph is placed in each chamber to record temperatures on a weekly chart. Suitable wooden racks, 2 feet wide and of a total running length of 90 feet, have been fitted in each chamber for keeping the trays and boxes of fruit and vegetables for the experiments. "Day-light" electric lights have been provided in each chamber so as to get a better idea of the colour of the fruit.

The whole plant is fully automatic. Each chamber is fitted with a thermostatic switch which automatically turns on the brine circulation and, with it, the fan for the circulation of air in the chamber, when the temperature of the chamber gets higher than the temperature to which it is regulated. The brine circulation and the fan are automatically turned off when the regulated temperature is attained. The brine temperature is also automatically controlled. The compressor starts working as soon as the temperature of the brine rises above the regulated range and it stops when the brine is cooled down to the required temperature. A stand-by compressor and a brine pump have been provided in order to prevent any stoppages in case of a breakdown of the compressor or the brine pump.

III. IMPORTANT FACTORS INVOLVED IN COLD STORAGE

It was the object of these investigations to obtain practical data regarding the conditions under which Indian fruits and vegetables should be handled in cold storage and transport, to ascertain what varieties are most suitable for commercial storage and what results may be expected under reasonably favourable conditions. There are reasons to believe that, given such fundamental data, commercial enterprise will be willing to step in and develop a trade which has obvious possibilities. In consequence attention has been devoted mainly to the biological aspect of the problem.

1. Temperature

The question of temperature is, of course, of the greatest importance. A fruit or vegetable is a living organism which respires, taking in oxygen and

giving out carbon dioxide. In cold storage the "life" of the produce is extended, because the low temperature slows down the life processes going on in the fruit or vegetable and also retards the development of the micro-organisms which are responsible for the decay. The low temperature must not put a stop to the life processes but only retard them. It is, therefore, wrong to suppose that the lower the temperature the longer the "storage life" of the produce. The possibility of low temperature breakdown and freezing injury sets a limit to this. For every kind of fruit or vegetable there is a certain range of temperatures suitable for its storage which must be determined by experiment. Variations of two or three degrees above or below a desired temperature are often too much and must be avoided.

2. Humidity

In addition to the temperature, the humidity in a storage chamber is also very important. If it is too low, wilting is likely to occur in most fruits and vegetables. If it is very high, a condensation of moisture on the produce is possible, as a result of fluctuations in the temperature. It has generally been observed that a humidity of 80 to 90 per cent. gives the best results. Various methods have been proposed or tested from time to time for the control of humidity in cold storage chambers, but accurate control of humidity is rather difficult. It has, however, been found by experience that, when the storage chamber is filled with fruits or vegetables, a suitable humidity, between 80 and 90 per cent., is usually obtained. If it is found necessary to increase the humidity, this can be done by keeping the floor moist or by exposing shallow basins of water in the chamber. For decreasing the humidity a drying agent such as calcium chloride may be used.

3. Composition of the Air in the Chambers

The ordinary air of the atmosphere contains roughly 79 per cent. of nitrogen and 21 per cent. of oxygen with traces of carbon dioxide and water vapour. The fruit or vegetable in storage respires and gives out carbon dioxide gas at the expense of the oxygen in the air. The percentage of carbon dioxide is found to increase steadily in a cold storage chamber which is air-tight. The amount of carbon dioxide in the atmosphere of storage chambers has been found greatly to influence the "storage life" of the fruit. The presence of carbon dioxide up to a certain concentration in the storage atmosphere has been found to be beneficial and the new method of gas-storage, requiring careful control of the composition of the air of the storage chambers, has recently been developed. Higher concentrations of carbon dioxide have been found to be harmful. In a cold store, the usual proportion of nitrogen and oxygen is maintained by preventing an accumulation of appreciable amount of carbon dioxide. This is accomplished by opening the doors at the time of the examination of the stock or at the time of loading or unloading. In some cases artificial ventilation is resorted to and in others the air is completely changed at regular intervals.

4. Changes observed during Storage

In storage, there is a constant evaporation of water from the surface of the produce, the extent of which depends on the nature of the produce, the

temperature and the relative humidity of the storage chamber. Along with the evaporation of water there is a continuous process of respiration going on in the produce which consumes certain substances present in the fruit or vegetable. The united effect of these two changes results in a loss in weight of the produce. As a result, the produce in some cases may show wilting or shrivelling.

There are three causes by which the fruit or vegetable in cold storage is rendered unsuitable for consumption, *i.e.*, by chilling, physiological breakdown or fungal rotting. The symptoms of chilling are usually (1) change in colour, (2) development of pits or sunken areas on the skin and (3) in the case of fruit, failure to ripen properly. Physiological breakdown is an internal change of the fruit or vegetable and is usually not recognizable from the outside. The pulp is affected and, in some cases, dark brown areas develop. In others, internal fermentation sets in, giving the pulp a fermenting and bitter taste. Fungal rotting is visible by the development of dark brown areas on the skin or the appearance of the coloured fructifications of the fungus associated with a softening of the tissues.

5. Selection of Fruit for Cold Storage

Even in ordinary storage all the varieties of fruit do not behave equally There are some which are classed as " good keepers " and others as " bad keepers ". In cold storage too, all the varieties do not keep well equally but differ in their cold storage behaviour. It is never certain that the " good keepers " in ordinary storage will be so in cold storage as well. It is possible that the " bad keepers " in ordinary storage may be " good keepers " in cold storage. For the successful cold storage of the produce it is, therefore, necessary to carefully study the behaviour of a number of commercial varieties of one kind of fruit in order to select the varieties suitable for cold storage.

It has been found that the cold storage behaviour of the fruit of a variety depends on the locality of its production, the age of the tree and cultural treatment. The storing quality of the fruit of a particular variety from one and the same locality may also vary according to the time of picking.

The stage of maturity or development of the fruit at which it is plucked off the tree is very important. Successful cold storage largely depends upon the fruit being obtained at the right stage of maturity. Although immature fruit may possibly keep the longest in sound condition, it may shrivel and may not attain perfection as regards colour, texture, taste and aroma. On the other hand, if the fruit is fully mature or ripe and soft, it may be chilled at the low temperature of storage or may only be kept for a short time in good condition. It follows that a stage of maturity between these two extremes, ensuring a good quality and long storage life should be determined experimentally by storage trials.

6. Treatment of Fruit before Storage

Fresh fruit intended for cold storage must be free, as far as possible, from skin breaks, bruises and decay. Even if the injured fruit could be kept in cold storage for a time without immediate decay, rapid deterioration is bound to take place as soon as it is removed to ordinary temperatures. Careful selection of the fruit is, therefore, necessary.

In some cases pre-storage treatments, such as washing the fruit with a disinfectant fluid, may lead to a reduction of rotting. In others wrapping the fruit with different kinds of paper may be advantageous. The method of packing, the type of package to be used, the nature of material to be employed in packing and the way in which the packages are stacked in a cold store are factors which must also be examined.

IV. RESULTS OF THE COLD STORAGE INVESTIGATIONS

The investigations were started in March, 1934, and the results obtained until now have been summarized below. The investigations on the storage of the mango have been made in detail and the influence of the important factors mentioned previously has been studied. The investigations on the orange are not yet complete. Preliminary storage trials on a few other kinds of fruits and vegetables have also been carried out.

1. Mango

It is of interest to note that Alphonso mangoes have been successfully shipped to England, in varying quantities and with varying results since 1932.

(*a*) *Temperature.*—The range of temperature found suitable for its storage was from 45° to 48°F. 43°F. was too low for satisfactory storage. The fruit was chilled at temperatures below 45°F. and the green unripe fruit did not ripen satisfactorily when removed to 68°F. or to room temperature, after storage. Pitting of the skin was very severe at low temperatures and the fruit rotted when removed to room temperature. At temperatures higher than 48°F. wastage was rapid. There was a development of bright yellow colour in fruit ripened at 68°F. and this was more marked in the fruit of varieties, such as the Peter, Pyree, &c., which normally do not develop a good colour.

(*b*) *Humidity.*—The relative humidity was maintained between 80 and 90 per cent. and has given good results. The effect of varying degrees of humidity has not yet been investigated ; its study has been postponed to a later date.

(*c*) *Stage of maturity.*—The ripe yellow fruit (eating maturity) of all the varieties investigated, except Fazri Zafrani and Kolanka Goa, turned brown in cold storage at 52°F. and the lower temperatures. The green unripe fruit which was just mature (the so-called " A " stage) was not suitable for cold storage, as it shrivelled and did not develop a sweet taste. Unripe fruit, fully mature and just showing faint signs of a change of colour (" C " stage), was chilled in cold storage and partially developed a brown colour. Fruit which was properly developed and yet green and hard (" B " stage) was found very satisfactory for cold storage.

(*d*) *Variety.*—There are innumerable varieties of mango grown in India. A few varieties which are famous in the different provinces in India were tried in cold storage. In all, twenty-eight different commercial varieties of mango from the Madras Presidency, the United Provinces, Bihar and the Bombay Presidency, were tested. Some of the varieties included in the storage trials were Peter, Suwarnarekha and Banganpalli from the Madras Presidency, Langra, Jardalu and Hemsagar from Bihar, Benarsi Langra, Fazri Zafrani and Fazri White from the United Provinces, Alphonso, Pyree, Shendrya, Batli and Fernandez from the Bombay Presidency.

The Alphonso variety, which is superior in ordinary storage, also led in cold storage as it was found to be the best keeper. The fruit of B stage of maturity could be kept at 45° and 48°F. for seven weeks in good condition and could be ripened afterwards satisfactorily. The maximum storage life of the fruit was about nine weeks at 45°F.

The fruit of the varieties Peter, Fazri Zafrani, Pyree and Cawasjee Patel, could be also kept in good condition for varying periods. The fruit of the Peter, Pyree and Cawasjee Patel varieties could be kept for four weeks at 48°F., seven weeks at 45° to 48°F., and nine weeks at 45°F. respectively. Though the fruit of the last variety showed good keeping quality, it is of an inferior type for table use. The ripe fruit of Fazri Zafrani could be kept in good condition for five weeks at 43° and 45°F.

The ripe fruit of the Langra and Jardalu varieties is very sweet. The market value of this fruit was lost as the colour of the skin turned brown in cold storage. The pulp of the fruit was not affected and the fruit could be preserved for the sake of its sweet pulp for six weeks at 43° and 45°F.

Further investigations were carried out on the fruit of the Alphonso variety. It was found that the unripe fruit when transferred to room temperature after cold storage ripened perfectly and developed the normal percentage of sugars. The rate of ripening of the fruit, however, slackened as the length of the storage period increased. The aroma of the Alphonso fruit was lost to a certain extent in cold storage.

The size of the fruit has been found to be of little importance as far as the storage quality is concerned. Both the big and the small-sized fruit of the same stage of maturity behaved similarly. But it is better for commercial purposes to have in one package fruits of uniform size as far as possible. The fruit having a portion of the stalk-end attached to it after being plucked has no advantage in storage life. The fruit with a short stalk-end is, however, preferred as it gives a cleaner and brighter appearance. The gum oozing out from the broken stalk-end is sticky and developes brown spots on the fruit in cold storage. There is no objection to store the fruit with the stalk-end broken off, as long as it is clean.

Most of the decay of the fruit was due to a fungus (*Gloeosporium mangiferae*), which appeared as stem-end rot, lateral rot, watery rot and " brown patches". Different pre-storage treatments such as washing with antiseptic solutions or smearing with antiseptic powders were of no advantage. It appears that the fruit with high acidity keeps longer than the fruit with low acidity. Apart from chilling, the only physiological breakdown is darkening of the pulp around the stone which was observed in every variety usually after nine weeks at 45°F. At the higher temperatures this development was found earlier.

The storage behaviour of the fruit of the Alphonso variety obtained from the five localities, Ratnagiri, Poona, Thana, Surat and Dharwar, well-known for the cultivation of this fruit in the Bombay Presidency, did not show a marked difference except that the fruit from Dharwar was inferior in keeping quality. The fruit from Ratnagiri remained green and hard for a longer period in cold storage as compared with the fruit from the other localities.

Wrapping the fruit individually either with tissue paper or waxed paper impaired the ripening power of the fruit after cold storage and the fruit when unwrapped quickly rotted at room temperature. Packing material like rice straw and wood-wool did not affect the fruit while in cold storage but vitiated the subsequent ripening to a certain extent.

A wooden crate of the size of 24 in. × 12 in. × 12 in., capable of holding about a hundred mangoes, was found to be a suitable kind of package for commercial cold storage. As wrapping the fruit individually was found to be harmful and as packing materials, like rice straw and wood-wool, affected the ripening of the fruit, wrapping of the fruit and packing it tightly with the packing material should be avoided, using only a light wadding of the packing material to hold the fruit in position and minimize bruising. The arrangement of the crates inside a cold chamber must be so planned as to ensure a good circulation of air and a uniform temperature.

Summary of Results regarding Cold Storage of Mangoes

(1) So far as these experiments have gone, the best varieties of mangoes for cold storage are, in order of merit :—

The Alphonso from Bombay, Pyree, Cawasjee Patel from Bombay, Peter from Madras, Fazri Zafrani from the United Provinces.

(2) The best stage of maturity for preserving the Alphonso Mango is the so called B stage, *i.e.*, when the fruit is full sized and just before it begins to turn yellow.

(3) At a temperature of 45°F. (with a variation not above 48°F.) the Alphonso variety can safely be kept in good condition for seven weeks and can be ripened satisfactorily afterwards. The maximum storage life may be as much as nine weeks.

(4) Mangoes for storage should be clean and free from gum-oozing from broken stalks. It is absolutely unnecessary to wash with antiseptic solutions or use antiseptic powder while paper wrappers definitely impair the ripening of the fruit after cold storage.

2. Orange

Cold storage trials of Nagpur oranges (the *Santra*) from the Central Provinces and of Malta oranges from the Punjab were carried out.

(*a*) *Nagpur orange.*—The green fruit did not ripen at 35°F. and 40°F. but became wilted and, after a period, assumed a brown colour and began to break down from inside. The fruit changed to a good yellow colour at 45°F. and 52°F. but by the time this change took place, most of the juice was lost.

Yellow oranges (fully ripe) kept their good outward appearance at temperatures from 35° to 52°F., but at the temperatures of 45° to 52°F. the inside pulp dried up quickly. At 35°F. the fruit could be kept for about two months but, on storage for a longer period, internal breakdown took place, the juice tasting bitter.

The yellow fruit and the fruit which was fully ripe but had not completely changed its colour could be kept in good condition for three months at 40°F. without any appreciable wastage. If the fruit was quite sound without an

injury to the skin there was practically no loss due to the growth of blue or green mould. There was, however, a little wastage due to *Alternaria* disease in which case the fungus grew inside and the black mass enveloped the entire pulp.

Wrapping the fruits individually with tissue paper was not of any great advantage but was useful in keeping the sound fruit out of contact with any rotting fruit. Pre-storage treatments, such as washing with borax, were found to be of no advantage, but in some cases definitely harmful.

As the fruit is loose skinned, there is a danger of the fruit being pressed down in a crate under the weight of the upper layers and thus of cracking the skin. In selecting the size of the crate and in packing, care should be taken that the fruit is not too much pressed.

(*b*) *Malta orange.*—Malta oranges which have fully developed the orange colour could be kept at 40°F. for four months in good condition without any wastage. The fruit could also be kept at 35° and at 45°F. in good condition but for a shorter period. The size of the fruit is very important in cold storage. Fruit of big size remained quite firm and also retained the original colour while the fruit of smaller size shrivelled and changed to a dull colour.

When the fruit was carefully selected there was practically no loss due to fungi. Only a few fruits partially changed the colour of the skin to brown and the skin became leathery. There was no particular advantage in wrapping the fruit individually with tissue paper. There is not much difficulty in packing the fruit in a crate as the skin is quite rough and does not easily break.

Summary of Results regarding Oranges

1. So far as these experiments have gone, the best oranges for cold storage are, in order of merit :—

(1) Malta oranges.

(2) The Nagpur orange (*Santra*).

2. The best stage of ripeness for storing oranges is—Malta oranges—when they are full sized and have fully developed the orange colour. For the Nagpur orange the fruit should be full sized and fully ripe.

3. At 40° F., Malta oranges will keep for four months and Nagpur oranges for three months.

4. If fruit is unjured there is no deterioration in cold store. Pre-storage treatments, such as washing with antiseptics or wrapping with papers, are of no advantage.

3. Other Fruits and Vegetables

Only preliminary storage trials of the following have been made :—

Peaches.—Peaches of the varieties, Elberta and 6 A, grown in the North-West Frontier Province could be kept in good condition for a month at 35°F.

Bananas.—The bananas of two varieties from Madras, Sirumalai and Karpura Chakkarakeli, ripened normally at 56°F. and could be kept for two weeks while the fruit of another variety, White Chakkarakeli, remained in good condition for about four weeks at 56°F. though the appearance was not very satisfactory.

The bananas of the Basrai variety from Poona got chilled at 56°F. and could not be ripened properly when kept at a higher temperature. The fruit ripened normally at 60° and 68°F. and was in good condition for three weeks at 60°F., and for two weeks at 68°F. The fruit of this variety did not get a good colour when ripened in the ordinary way, but storage at 68°F. developed a good yellow colour on the fruit.

Chikoo (Achras sapota).—The unripe fruit received from Baroda was chilled at 45°F. and the lower temperatures and could not be ripened after storage when removed to room temperature. The fruit ripened normally at 52° and 56°F. and remained in good condition for four to five weeks.

Litchi.—The ripe fruit from Bihar could be kept in good condition for three months at temperatures from 30° to 45°F. It could be kept even longer at 35°F. The red colour of the fruit, however, turned brown in storage and the shell became harder.

Apples.—Four varieties of apples from Chaubattia, *viz*., Delicious, Jonathan, Stummer Pippin and Norfolk Biffin, were tried. The variety Delicious was found to be the best keeper, as the fruit was in very good condition even after eight months of storage at 32°F. The apples of the varieties Jonathan and Norfolk Biffin could be kept at 32°F. for about eight months without rotting, but the fruit shrivelled very badly. The fruit of the Stummer Pippin variety showed internal breakdown after four months.

Lemons.—Eureka lemons received from Sind could be kept in good condition at 40°F. for two months.

Potatoes.—It was found that seed potatoes of Khabrar and Garhwal varieties received from the Kumaon Hills, Mahableshwar Hill potatoes and the potatoes from Khed (near Poona) remained in dormant condition at 35°F. for about a year and the germinating power of the seed tubers was not much affected even after ten months of storage at 35°F. The relation of the temperature and the period of storage to the yielding capacity has not as yet been tested. For table use the Khed potatoes could be kept for about six months without sprouting at 40°F. The tubers sweetened at the lower temperature of 35°F.

Cabbage.—Cabbage (variety, Large Drumhead) could be kept at 32°F. for about six months in good condition. When stored for a longer period the development of a pale yellow colour on the inner leaves took place. The loss in weight during the storage period was about 35 per cent. when stored in open trays and less if stored in crates. " Solid " heads of cabbage kept better than the " loose " heads.

Cauliflower.—Cauliflower (variety, Early Snowball), if stored without any wrapping, did not keep in good condition even for a week at 32°F., but shrivelled very badly. The cauliflowers when wrapped in waxed paper or in their own leaves could be kept in a satisfactory condition for about two months at 32° and 35°F.

French beans.—French beans (local) could be kept in good condition at 32°F. or 35°F. for three weeks. The temperature should not be allowed to fall below 32°F. as the beans appear " blanched " and are quickly overgrown with fungus.

Peas.—The garden peas of Poona variety (in pods) could be kept at 32° or 35°F. for four weeks. It was necessary to store the peas in thin-mesh gunny bags in order to avoid the heavy loss of water from the pods. The temperature should not be allowed to fall below 32°F. in order to prevent freezing.

Carrots.—Carrots (country variety) could be kept at 32° and 35°F. for about three months in good condition but the tips dried and a fungal growth developed on storage for a longer period.

Onions.—" Young " onions remained in good condition for about two months at 32° and 35°F. Fully developed onions of both the red and the white country varieties could be kept without sprouting at 32°F. for more than six months. Generally the white onions appeared to be a little inferior to the red onions in storage quality.

V. PRE-COOLING AND TRANSPORT

To enable fruit to be brought from distant stations special experimental refrigerated containers have been made for the safe transport of the experimental material The containers are insulated boxes, weighing about 115 lbs., and are refrigerated with water ice. If the container together with the fruit is pre-cooled and then a charge of ice is given, a temperature of about 40° to 45°F. can be maintained during the transit period. The difficulty has been the total absence of any pre-cooling facilities at the places from which the fruit is obtained for the experiments. The containers charged with ice without pre-cooling give a temperature range of about 65° to 70°F. which is about 20–25° lower than the atmospheric temperature. It was possible to obtain litchis in good condition for cold storage trials from Bihar by using such a refrigerated container for their transport. Ordinarily the fruit is spoilt in transit. For the transport purposes it is really necessary to pre-cool the produce.

Cold storage and refrigerated transport go hand in hand. Even when the produce can be satisfactorily stored, it is necessary to have suitable arrangement for its distribution at reduced temperatures without which the main object of cold storage in extending the area of distribution and in creating new markets cannot be fully achieved.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MARCH 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Blackquarter	1	..	1	..	..	..
	Rabies	1	..	..	..	..	1
	Piroplasmosis	2	2	..	..	2	..
	Rinderpest	9	9	..	2	..	7
Colombo Municipality	Foot-and-mouth disease	25	10	2	22	..	1
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Piroplasmosis	3	1	..	3	..	..
Cattle Quarantine Station	Foot-and-mouth disease	1	1	..	1	..	..
	Anthrax	26	12	26	..	..	..
Central	Foot-and-mouth disease	79	39	..	46	33	..
	Anthrax	1	..	1	..	..	..
	Rabies	7	3	2	..	..	5
	Contagious mange	12	6	..	4	8	..
	Piroplasmosis	5	..	1	4	..	..
	Blackquarter	8	7	8	..	..	..
Southern	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	1	1	..	..	..	1
Northern	Foot-and-mouth disease	130	21	7	123	..	..
	Rabies	..	..	..	..	..	..
Eastern	Foot-and-mouth disease	2	..	..	2	..	..
North-Western	Foot-and-mouth disease	122	112	1	46	75	..
	Goat Pox	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Contagious mange	..	..	..	..	..	..
	Rabies	1	..	..	..	..	1
North-Central	Foot-and-mouth disease	1,287	11	..	1,276	11	..
	Blackquarter	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
Uva	Foot-and-mouth disease	58	58	1	42	15	..
	Rabies	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
Sabaragamuwa	Foot-and-mouth disease	..	..	..	..	..	..
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, April 19, 1939.

A. JAYASINGHA,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, MARCH, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	89·0	+1·4	73·2	—0·7	64	90	4·2	3·39	6	— 1·48
Puttalam ..	91·2	+1·8	72·5	0	66	90	4·4	1·36	4	— 1·97
Mannar ..	90·2	+0·6	74·7	—0·5	67	88	5·0	0·27	1	— 1·45
Jaffna ..	89·0	+0·7	75·2	—0·3	67	86	2·6	0·10	1	— 1·73
Trincomalee ..	85·4	+0·3	75·3	—1·2	74	91	2·8	1·20	4	— 1·16
Batticaloa ..	85·8	+0·6	74·8	—0·2	74	90	2·7	0·25	3	— 3·10
Hambantota ..	86·8	+0·2	73·8	—0·2	72	88	3·6	5·23	8	+ 1·40
Galle ..	86·0	—0·4	74·9	—0·1	74	88	4·3	1·82	7	— 4·39
Ratnapura ..	93·7	+2·0	71·7	—0·8	64	93	4·3	8·09	20	— 2·86
Anuradhapura ..	92·9	+2·5	68·6	—3·1	58	95	3·0	0·60	4	— 3·04
Kurunegala ..	95·6	+3·9	71·1	—0·7	49	93	5·2	4·90	10	— 1·08
Kandy ..	91·9	+4·6	67·4	—1·2	54	87	2·6	2·57	5	— 3·26
Badulla ..	82·3	+0·4	62·6	—1·8	61	94	3·4	2·79	7	— 2·78
Diyatalawa ..	79·4	+2·7	57·0	—1·1	54	80	4·8	2·51	9	— 2·44
Hakgala ..	75·3	+3·2	50·5	—1·7	65	81	4·2	1·81	6	— 4·89
Nuwara Eliya ..	72·2	+1·8	44·1	—2·5	52	85	5·0	1·56	8	— 2·76

Drought conditions continued into March, and the rainfall for the month was in deficit nearly throughout the Island, excesses being confined to less than 20 stations irregularly distributed. The largest excess was 5·64 inches at Keenagahaella, while excesses of 2–5 inches were reported from Mahawalatenna, Kumbukkan, Pelmadulla and Buttala. An appreciable number of stations, mainly on the lower western slopes of the hills, and in the adjoining low-country, recorded deficits of over 5 inches for the month, the largest deficits being 9·95 inches at West Haputale and 9·04 inches at Uggalkaltota.

The highest monthly totals were 17·21 inches at Keenagahaella, 14·18 inches at Mahawalatenna, and 12·13 inches at Pelmadulla, while seven other stations, mainly in the same area, recorded totals of over 10 inches. Nearly all the stations in the northern half of the Island recorded less than 2 inches for the month, an appreciable number, mainly in the Jaffna Peninsula and southwards towards Trincomalee, reporting no rain at all for the month.

Only one daily fall of over 5 inches was reported during the month, 5·10 inches at Galagoda, on the 14th.

The weather during the first two-thirds of the month was predominantly dry, such rains as occurred being generally light, and chiefly as a result of thunderstorm activity. An appreciable increase of rainfall occurred on the 22nd and the two succeeding days, due to increased thunderstorm activity. After three days of diminished rainfall, it increased again on the 28th, and weather conditions continued wet over a large part of the Island, chiefly in the southern half, till the end of the month. On the 31st the rain was fairly heavy at many places. Thunderstorm activity was well in evidence during the last third of the month.

Day temperatures were above, and night temperatures below normal. Humidity and cloud were both generally in deficit. The barometric pressure was also below normal. The wind, on the whole, showed no marked deviations from normal strength, while its direction was variable.

A hailstorm was reported on the 2nd from Hiniduma, and another on the 28th from Maliboda Estate, Deraniyagala.

H. JAMESON,
Superintendent, Observatory.